NASA Tech Briefs

Official Publication of the
National Aeronautics and
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June 1993 Vol. 17 No. 6

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SPECIAL FOCUS:

IMAGING TECHNOLOGY

Data acquisition hardware and software solutions for IBM PC/XT/AT PS/2 and Micro Channel computers and compatibles.

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1993
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Nobody puts together your PC-based data acquisition systems like Keithley. And our new *Data Acquisition Catalog and Reference Guide*, with the broadest range of software, PC boards, boxes, and applications support, is the only source you'll need in 1993.

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You'll find the complete line of Keithley MetraByte hardware ranging from plug-in boards to complete data acquisition instruments and systems. The DAS-1600 high-speed analog and digital I/O board, our patented Trigger Master™ system trigger controller, and the DAS-58 1 Msps board with 1 Megaword of on-board memory and optional simultaneous sample and hold are just a sample of the hundreds of products we offer.

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KEITHLEY DATA ACQUISITION

NT693

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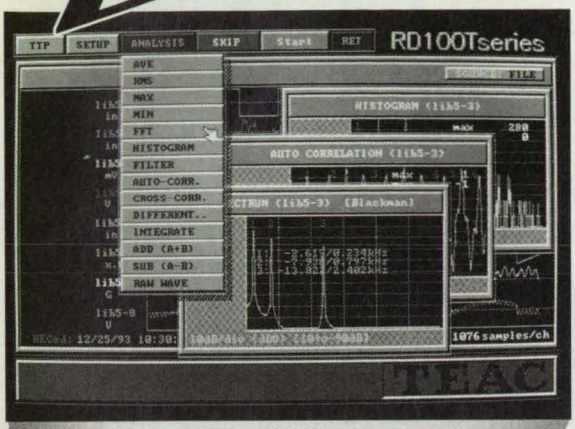

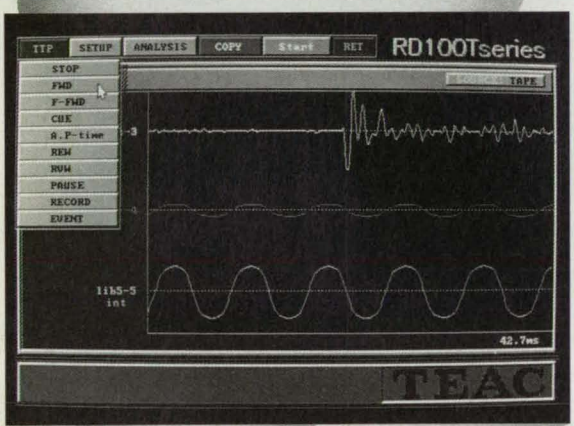

That's right! Our new RD-125T/135T Series dual speed DAT data recorders offer double the bandwidth of conventional, single speed DAT recorders - 4 channels at 20 kHz or 8 channels at 10 kHz. Plus, we've added a unique option, *QuikVu*™, powerful new data acquisition software that lets you set triggers, preview information and review data as you're recording.

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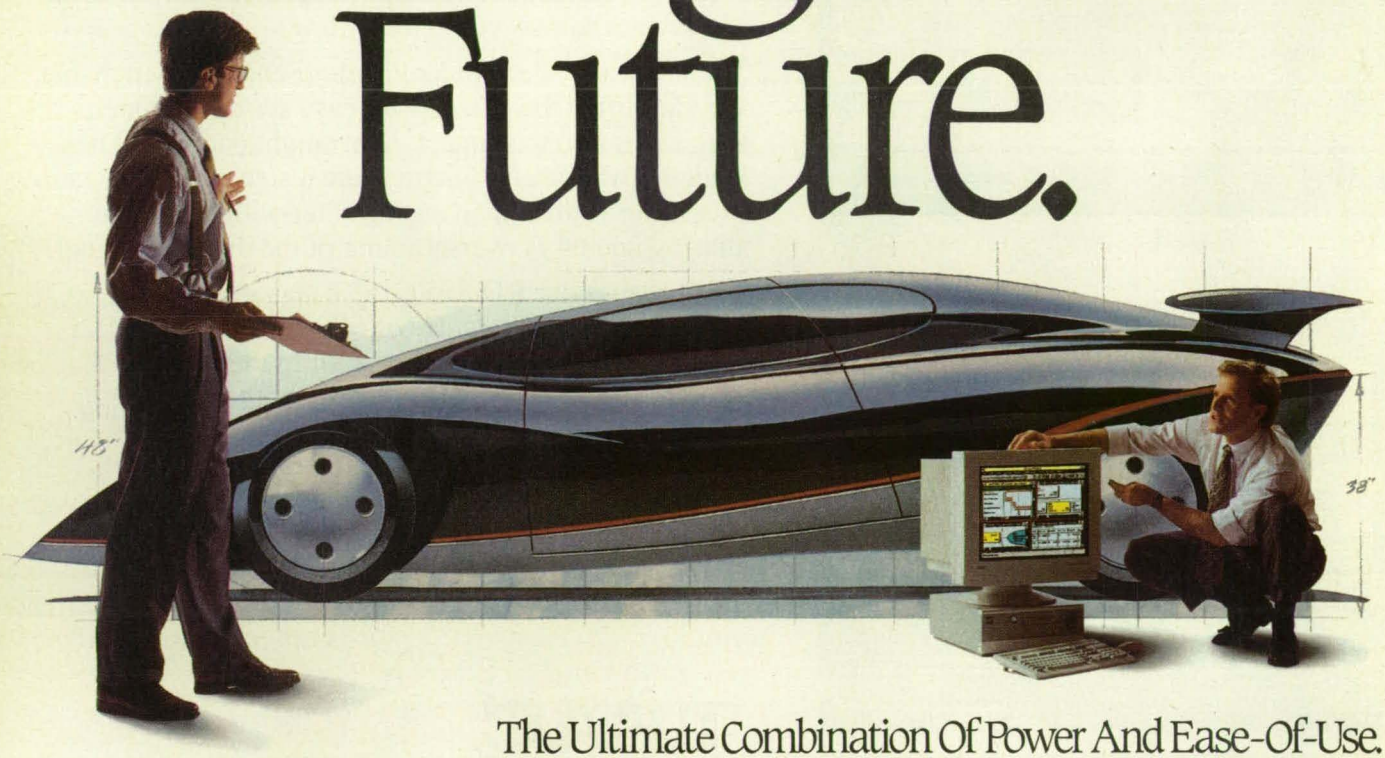

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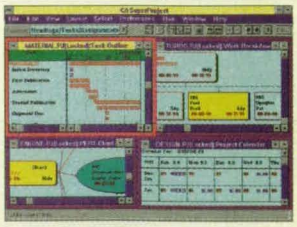

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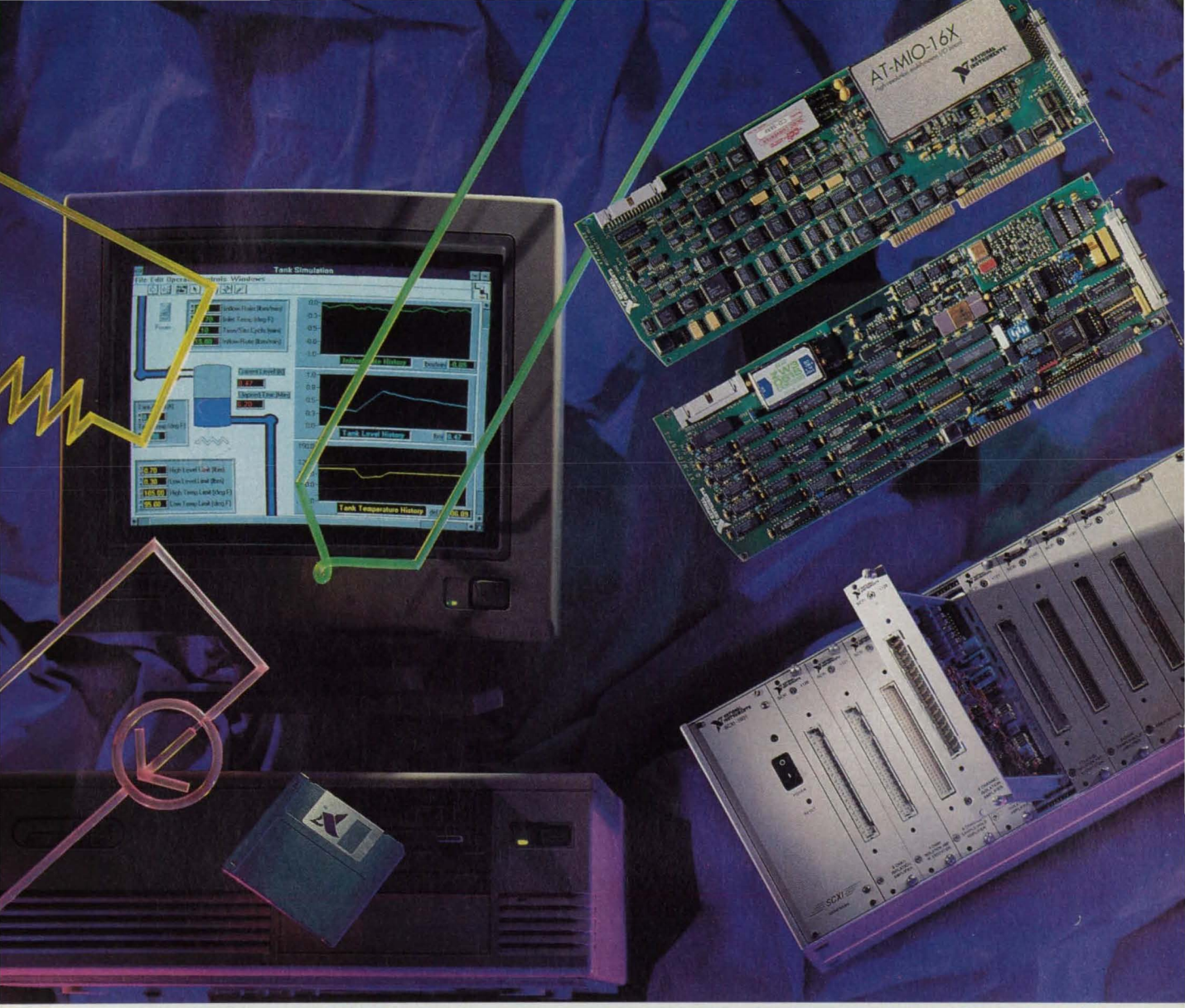

The Choice for Complete PC Data Acquisition Systems

National Instruments gives you more than the latest technology in plug-in boards.

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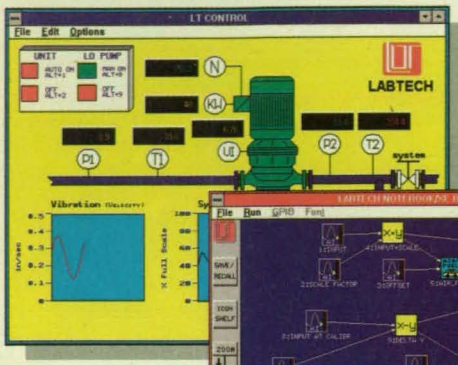
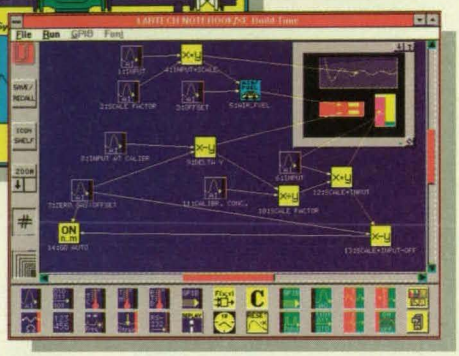
LABTECH®



Actual LABTECH CONTROL screen courtesy of Sundstrand Fluid Handling



With ICONview, you can set up your application by moving and connecting icons - no programming required

READERS' CHOICE '92

Winner of SC&A Reader's Choice Award

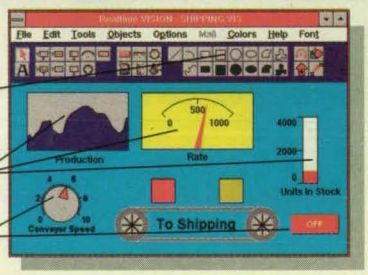
Real-Time Software

For over a decade, LABTECH has been providing high performance, low-cost solutions for real-time PC-based data acquisition and control. Now, LABTECH also offers real-time DDE data visualization.

REALTIME VISION

DDE-Driven Dynamic Graphics

MICROSOFT® WINDOWS™ COMPATIBLE



Toolbar contains tools for creating real-time display screens with animated graphics

Charts and graphs show changing data as the changes occur

Knobs and buttons allow operator interface and control

Real time means you see changes as they occur. **VISION** provides you with the real-time information needed for success in today's quickly changing business climate.

VISION includes all software needed to immediately start monitoring PC performance, network performance, and changes in dBase files.

VISION displays dynamic data from DDE-enabled Windows applications.

Examples include:

- Microsoft Excel
- Lotus 1-2-3
- Borland Quattro Pro
- Visual BASIC
- databases

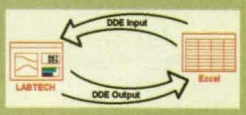
	List Price
Realtime VISION	$395
Developer's Edition (for royalty-free distribution of applications)	$995

Data Acquisition and Control

Real-Time Data Acquisition & Control LABTECH software has a built-in real-time scheduler that delivers "hard" real-time performance.

Widest I/O Hardware Support No one else supports more data acquisition boards! Over *500* data acquisition and control devices from more than *50* different manufacturers are supported. Call us to configure and purchase a complete hardware/software system.

Real-Time DDE LABTECH has real-time Dynamic Data Exchange (DDE) under Windows. Setting up a live DDE link is easy. Use the Copy command, Paste-Link and you're done!



LABTECH NOTEBOOK

Industry Standard for Data Acquisition

After nine years on the market and over 25,000 systems installed, NOTEBOOK is the most widely used data acquisition software package.

Features:

NEW Lower pricing starts at $495

- DOS and Windows versions bundled together
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- Triggering and pre-triggering
- Replay of stored data simultaneously with live data
- User-developed DLL icons in C
- Knobs, on/off buttons, switches and sliders for building user-interfaces

Options:

- Driver Toolkit for adding your own I/O drivers
- UNIX/X-Windows versions available
- Japanese, German, French versions available
- GPIB and RS232/422/485 support available

LABTECH CONTROL

Direct Digital Control From Your PC

CONTROL is different from other process control software packages provide *direct digital control* of the process in real-time. With CONTROL, you can configure an automated system using standard, off-the-shelf I/O hardware and industry-standard PCs. CONTROL includes all NOTEBOOK features, as well as the following:

Features:

NEW Lower pricing starts at $995

- On-line alarm logging and annunciation
- Animated process graphics with multiple views
- Logging by exception, with on-line notes
- Hot backup, auto failover fault tolerance
- SPC/SQC; PID auto-tuning options
- Sensor voting
- On-line setpoint changes and recipes
- PID anti-reset windup and bumpless transfer

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The fact is, when you write Ada code without using AdaMAT™ you're really putting the quality of your code at great risk. To be frank, you're actually inviting poorly written, unclear and inconsistent code that guarantees errors during development.

AdaMAT is quite simply, the most valuable and crucial software engineering tool that is available today to Ada program developers. It is the only tool for the prevention of errors during development. AdaMAT analyzes Ada code and evaluates it using key quality characteristics that are based on the most effective use of the language.

With the use of AdaMAT, potential errors are detected prior to testing. It lets programmers insure the quality of their code earlier in development when errors are much less time-consuming and costly to fix. So avoid the pitfalls. Get your project in on time and right on budget. Write clean, consistent, accurate, reliable Ada code. And do it whether you're developing in the Rational, VAX, SUN, or SCO/UNIX environments. Call us today at 1-800-522-7321 for complete information. We'd jump at the chance to tell you all about the immediate benefits you'll receive using AdaMAT for your Ada development.

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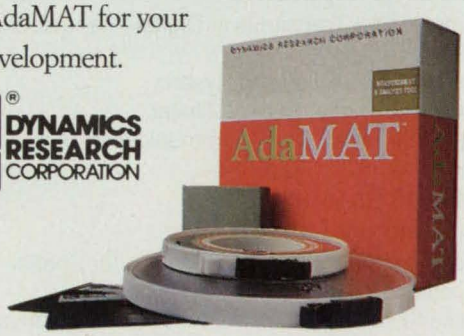

AdaMAT. The code word for quality Ada.

Dynamics Research Corporation, 60 Frontage Road, Andover, MA

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Volume 17 Number 6

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TECHNICAL SECTION

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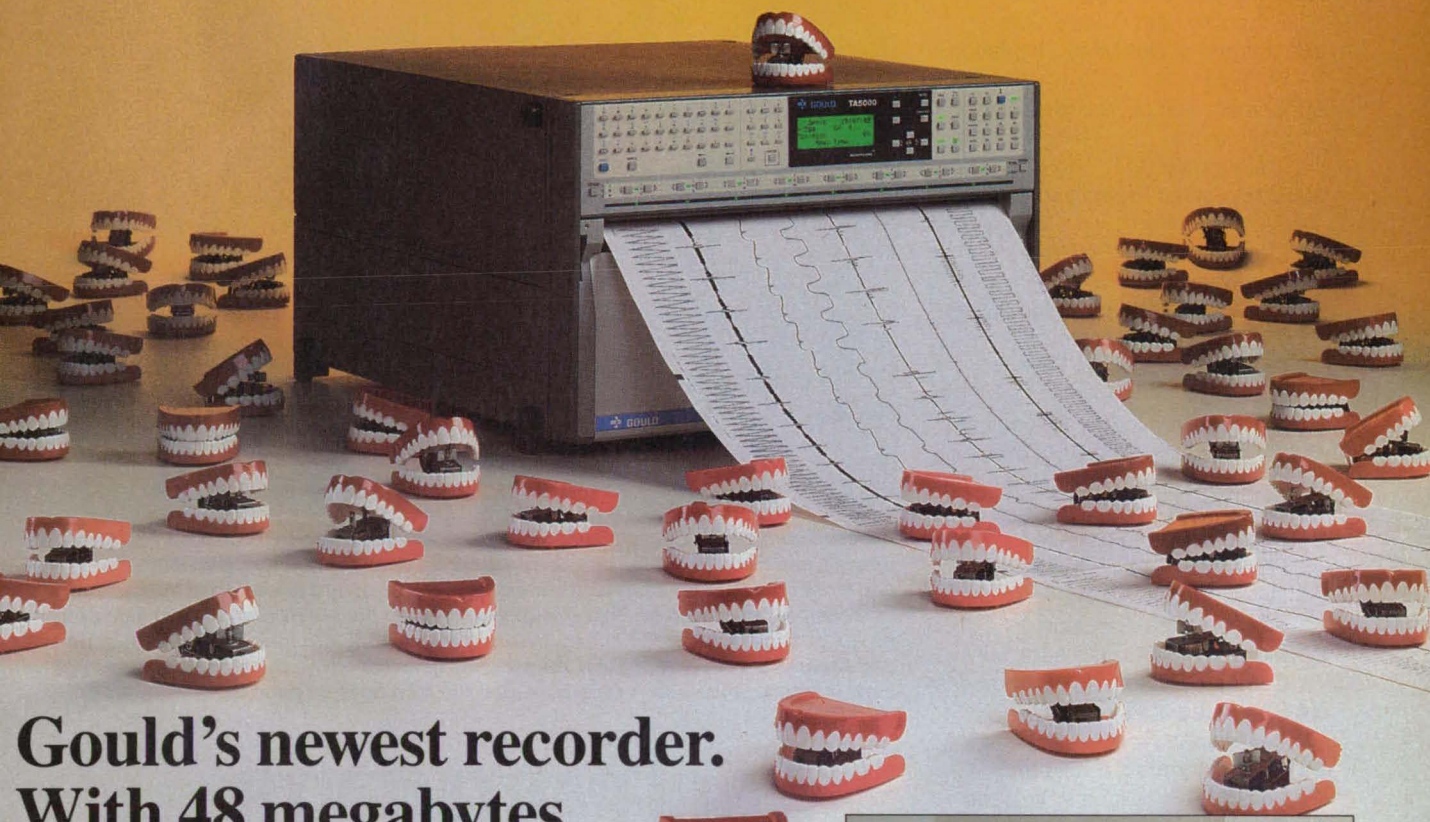
GOULD
Electronics



Gould's newest recorder. With 48 megabytes.

The new Gould TA5000 offers an unprecedented memory capacity that's bound to make you smile. This is the only 24-channel recorder with a 15″ thermal array printhead and up to 48MB of on-board memory. Which means you can record over longer periods of time *and* increase your sample rate to 250kS/s on all channels. So you're guaranteed the bandwidth you need for comprehensive analysis.

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In addition, Gould's Micropulsing™ technology provides reliable operation and the resolution you need to see your signals clearly, at every frequency and chart speed.

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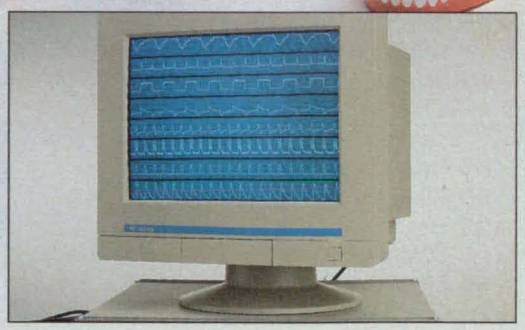
Call Gould today at (216) 328-7000 or, for immediate response, complete the coupon and FAX it to us today.



Set-up and display real-time signals with our new high-resolution (1280 x 1024) external monitor. A hand-held remote control allows selection of speeds, grid modes, annotation, and synchronization of the monitor to the chart from up to 100 feet away.

NTB 6/93

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(Please print, or affix business card.)

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Title: _____

Company: _____

Street: _____

City: _____ State: _____ Zip: _____

Telephone: _____

Send to: Gould Inc., Test and Measurement Group, 8333 Rockside Road, Valley View, Ohio 44125. Fax: (216) 328-7400.

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Contents *(continued)*

Photo courtesy Johnson Space Center

Pictured above is the simulated interior of an inflatable habitat proposed by Johnson Space Center engineers for use during lunar or Mars exploration. Providing living and working space for twelve crewmembers, the structure is enclosed by a strong multiple-ply fabric with an impermeable bladder on the inside and a thermal coating on the outside. A fabric bulkhead divides the structure into four functional quadrants and separates active from quiet zones: crew quarters above mission operations and crew support above base operations. See the tech brief on page 95.

DEPARTMENTS

on the cover:

This Magellan image centers on a volcano straddling a narrow fracture system near Phoebe Regio, one of Venus' highland tessera, or regions resembling mosaic tiles. It combines a synthetic aperture radar (SAR) backscatter image with a color radio-thermal emission image—red regions correspond to a high emissivity, blue to low. Emissivity, which is a measure of the electrical properties of surface materials, is an important clue to surface composition. Techniques recently developed at NASA for processing SAR images are discussed in the tech briefs on pages 28 and 89.

Photo courtesy Jet Propulsion Laboratory

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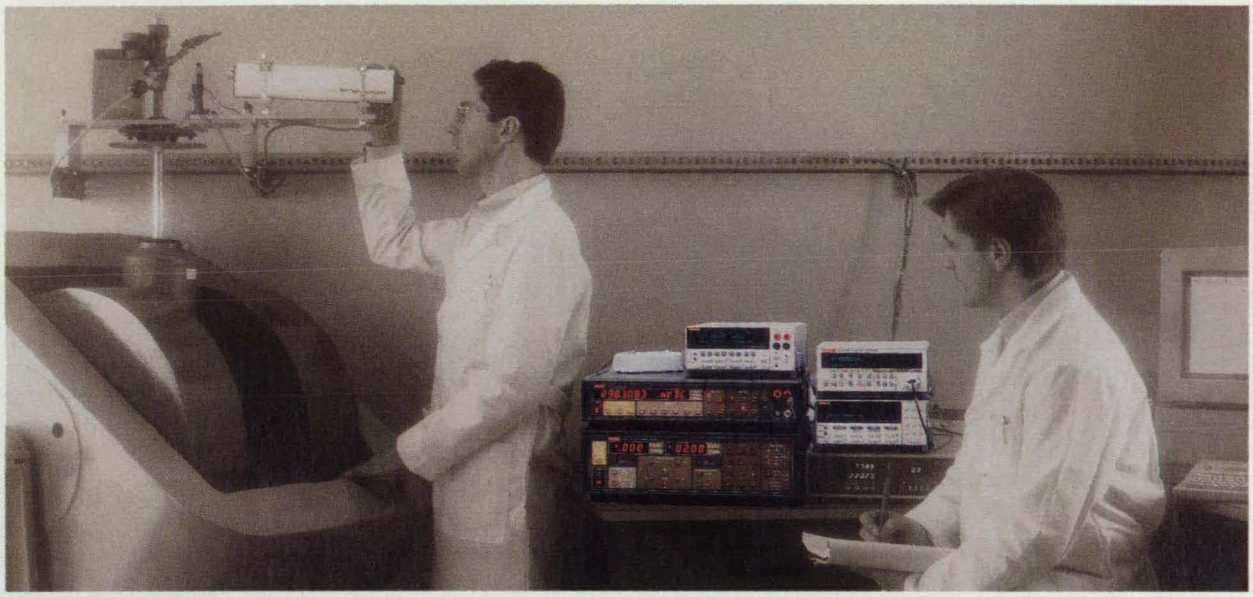
The leading players in R&D keep us on their bench.



Superconductive materials are reaching new heights in critical temperature and field. And Keithley is there.

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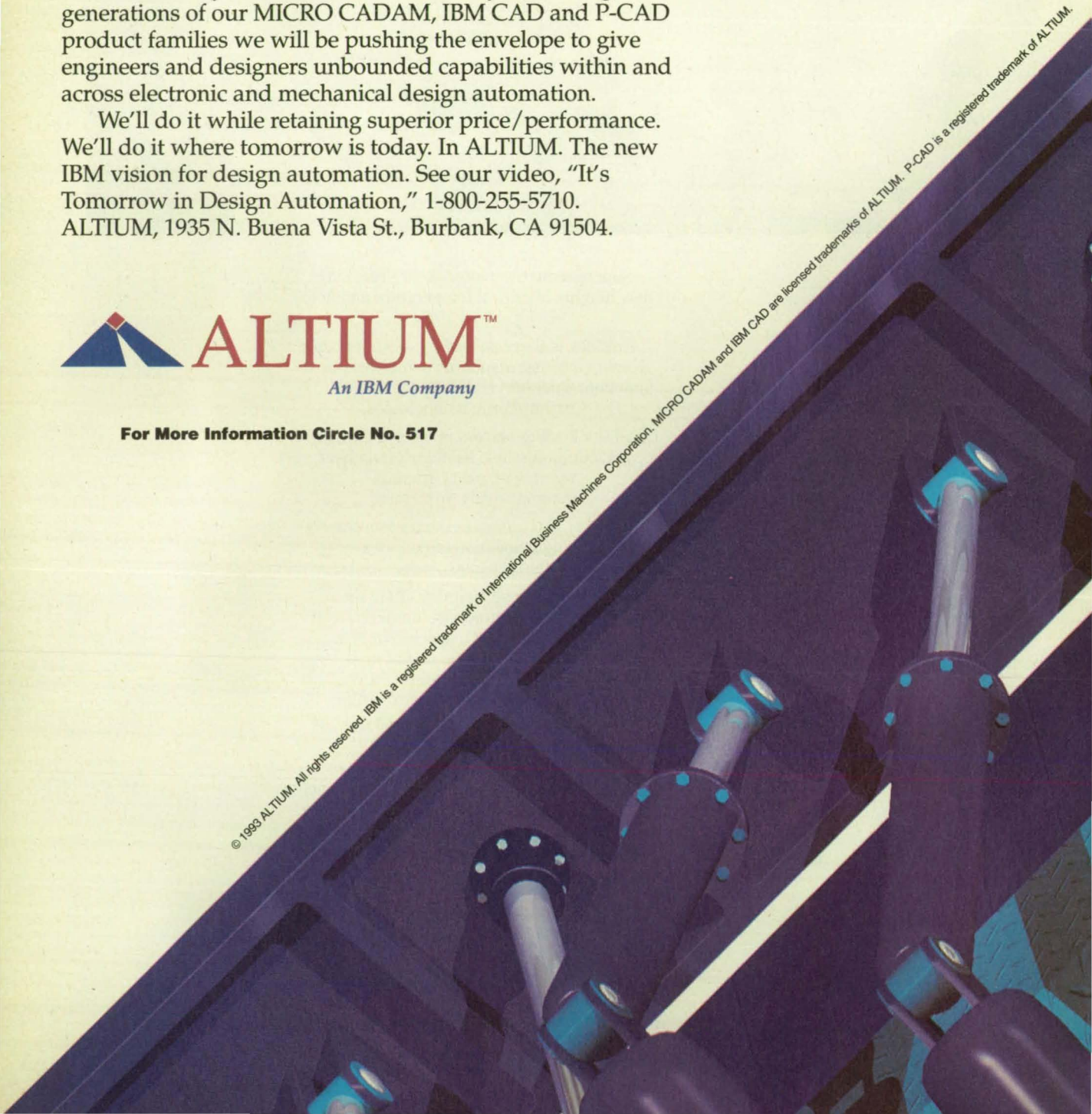

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For More Information Circle No. 530

NASA PATENTS

NASA has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Doppler Shift Compensation System For Laser Transmitters And Receivers

(US Patent No. 5,184,241)

Inventor: **Geary K. Schwemmer**, Goddard Space Flight Center

A new system permits simultaneous frequency tuning of laser transmitters and optical receivers on a low-orbit satellite. It compensates for doppler shifts caused by the relative motion between the system and a scattering object or between a laser transmitter and optical receiver located on different platforms. The invention comprises an absolute frequency standard stabilized laser source, a computer to calculate expected shifts, and a means to apply compensating frequency shifts to the stabilized source or to a tunable laser used as a transmitter.

For More Information Circle No. 550

High-Temperature Polymer From Maleimide-Acetylene Terminated Monomers

(US Patent No. 5,189,129)

Inventors: **Margaret K. Gerber** and **Terry L. St. Clair**, Langley Research Center

The inventors have prepared thermally stable, glassy polymers by mixing maleimide-acetyline terminated monomers with maleimide-containing monomers or oligomers and heating them to the temperature at which they react. The resulting polyimides are flexible, easy to process, and have high or nondetectable glass transition temperatures and high thermooxidative stabilities.

For More Information Circle No. 551

Long Wavelength Infrared Detector

(US Patent No. 5,185,647)

Inventor: **Richard P. Vasquez**, Jet Propulsion Laboratory

Mr. Vasquez has designed an infrared detector for wavelengths in the 10 μm to 100 μm range using III-V compound semiconductors that exhibit quantum confinement effects. The instrument is based on the photon energy absorption between two energy levels of coupled quantum wells, formed by the conduction band discontinuity between materials such as gallium arsenide. The width, depth, and spacing of paired wells are selected to split the energy level into two levels by interaction. Reducing the well spacing reduces the difference between the two levels for longer wavelength detection.

For More Information Circle No. 552

Method Of Making A Single-Layer Multi-Color Luminescent Display

(US Patent No. 5,194,290)

Inventor: **James B. Robertson**, Langley Research Center

Thin-film, multi-color electroluminescent displays offer flexibility, reliability, and reduced weight, space, and power consumption for such applications as control panels for air, space, and ground vehicles. Mr. Robertson's display uses a single layer of a host material, which itself may be a phosphor, that serves as a host to impurities within the layer to form a pattern of different colored phosphors. Impurities are introduced into the host by thermal diffusion or ion implantation.

For More Information Circle No. 553

Method and Apparatus For Determination Of Material Residual Stress

(US Patent No. 5,193,395)

Inventors: **Engmin Chern** and **Yury Flom**, Goddard Space Flight Center

A novel apparatus for determining residual stress is based on the discovery that sensor coil resistance and reactance monotonically increase and decrease with respect to externally applied stresses regardless of direction (tension or compression). If plotted on a graph of resistance versus strain, the coil's minimum resistance level corresponds to the specimen's zero stress state. The invention comprises an impedance gain/phase analyzer connected via cables to a sensor coil and a data acquisition/control device—in turn connected to a mechanical test machine—which processes data from the impedance gain/phase analyzer.

For More Information Circle No. 554

Modified Fast Frequency Acquisition Via Adaptive Least Squares Algorithm

(US Patent No. 5,195,051)

Inventor: **Rajendra Kumar**, Jet Propulsion Laboratory

The need to estimate the parameters of a sinusoidal signal arises in diverse engineering tasks such as carrier tracking for communications systems and measurement of Doppler in position location, navigation, and radar systems. Mr. Kumar has created a rapid and precise least squares scheme for the nonlinear estimation of the phase, frequency, and amplitude of a sinusoid.

For More Information Circle No. 555

System For Simultaneously Loading Program To Master Computer Memory Devices And Corresponding Slave Computer Memory Drives

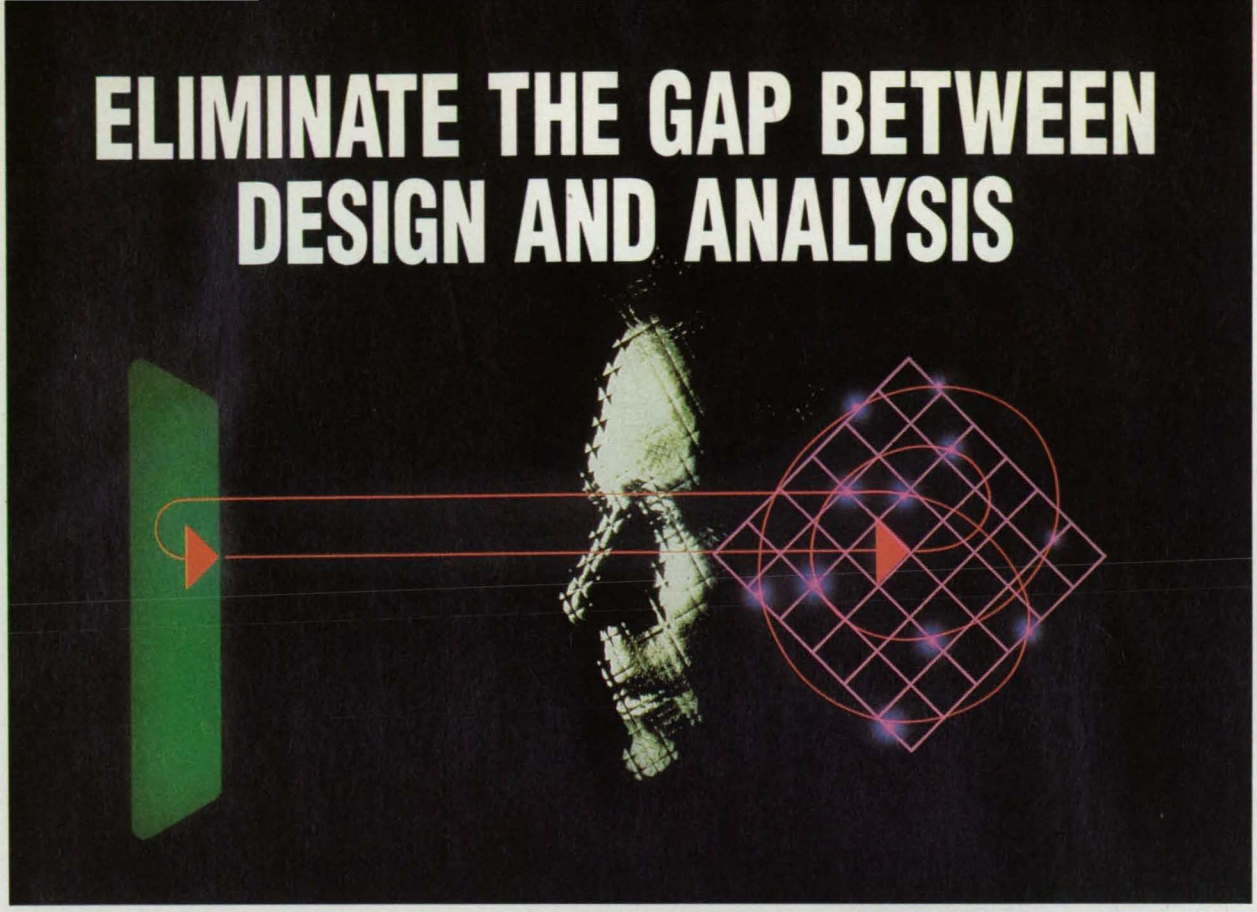
(US Patent No. 5,187,794)

Inventor: **William A. Hall**, Johnson Space Center

A bus-programmable slave module or card is designed for a multi-microprocessor computer system comprising a master computer and one or more slave modules interfacing via a standard data communications bus. Each slave module includes its own microprocessor, volatile and nonvolatile memory, and control program enabling it to act as a stand-alone, single-loop controller. A one-way electronic door between the master and slave computers is opened for programming mode, in which applications loaded onto the master are loaded in parallel onto the slaves, or closed for nonprogramming mode.

For More Information Circle No. 556

ELIMINATE THE GAP BETWEEN DESIGN AND ANALYSIS



Now all engineers can use advanced tools to make better designs because the two worlds of design and analysis are becoming the one world of predictive engineering. The power and scope of MSC's finite element analysis (FEA) capabilities now work hand-in-hand with the power of Aries Technology's solid modeling and automated meshing software. For the first time, both designers and analysts can work in the same solid-modeling-based environment, under one intuitive user interface, to rapidly create, analyze and optimize designs before expensive physical prototyping. Using predictive engineering for design optimization means higher quality, reduced development costs, and dramatically shortened time-to-market.

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ARIES TECHNOLOGY

For More Information Circle No. 457

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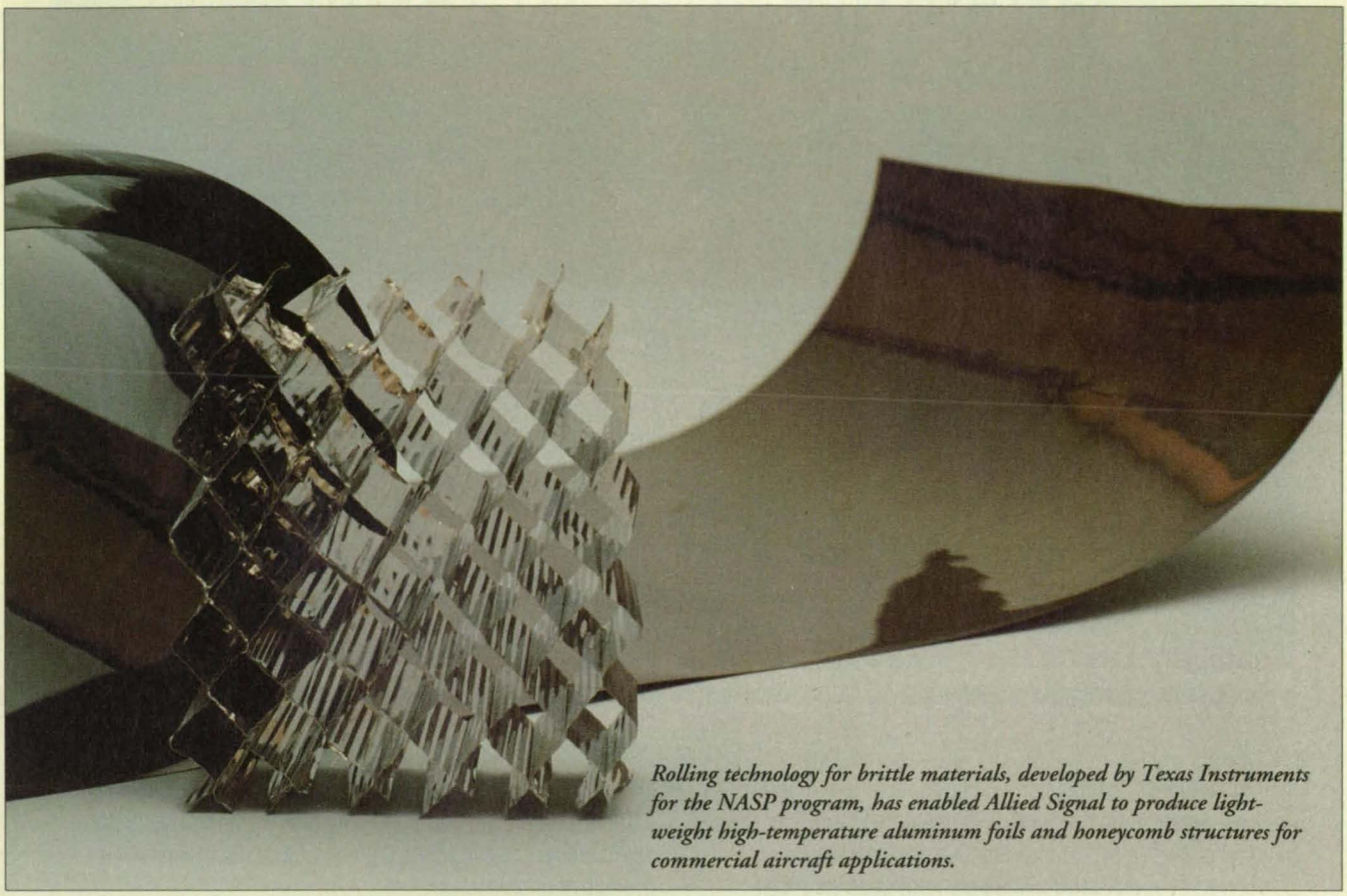


Rolling technology for brittle materials, developed by Texas Instruments for the NASP program, has enabled Allied Signal to produce lightweight high-temperature aluminum foils and honeycomb structures for commercial aircraft applications.

NASP SPINOFFS:

High Technology Comes Down To Earth

Far-reaching technologies that one day will propel the National Aero-Space Plane (NASP) into orbit—including high-performance materials, computational fluid dynamics software, and systems integration techniques—today are yielding advances for industry on Earth.

NASP is a joint Department of Defense (DOD)/NASA effort to develop a vehicle capable of single-stage-to-orbit operation. The hydrogen-powered aircraft would take off horizontally from a conventional runway and then reach the hypersonic speeds necessary to reach low-Earth orbit.

"The program has provided the opportunity to assemble and exercise a premier design and technology team that is thrusting the US into the 21st century," said Air Force Major William West, chief of NASP Technology Transition. Approximately 300 organizations in government, industry, and academia are working toward the program's objectives.

Successful NASP development is expected to produce tremendous cost and flexibility advantages over existing space launch systems as well as diverse civil and DOD spinoff applications. In just the last two years, the NASP program has generated more than $4 billion worth of technology transfers.

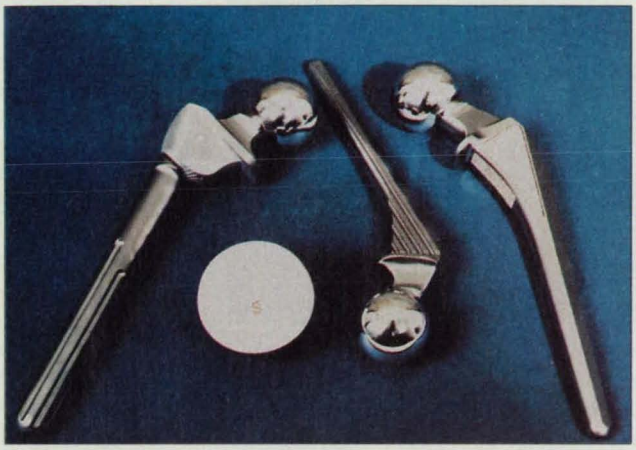
Materials development has been a particularly fruitful area for spinoffs. Spending significant time in the atmosphere to utilize its air-breathing

propulsion system will impose severe thermal and acoustical loads on the craft, subjecting it to temperature extremes greater than the space shuttle experiences on re-entry from orbit. To enable the plane to withstand such temperature cycling, NASP engineers are developing lightweight, high-strength, oxidation-resistant materials for airframe and engine structures, including metal matrix, organic, refractory, and highly-conductive composites.

One promising group of materials is titanium matrix composites (TMCs), which consist of a titanium metal or alloy reinforced with continuous silicon carbide fibers. TMCs have the strength of steel at half the weight and perform reliably at temperatures up to 982 °C, whereas unreinforced metals such as conventional steel can only withstand temperatures up to 427 °C. By contrast, materials such as ceramics and carbon-carbon composites can survive higher temperatures (up to 2204 °C), but do not have the high strength of TMCs. The composites' combination of properties makes them ideal for NASP's gas turbine engines and other high-temperature structures.

Last year, Textron Specialty Materials received an $8.9 million Air Force contract to develop the first TMC production facility for NASP and other applications such as commercial and military aircraft turbine engine components and commercial aircraft landing gear. The facility, located in Lowell, MA, is expected to be fully operational by July.

TIMETAL® 21S, a heat-resistant titanium alloy developed by Titanium Metals Corp. (Timet) for NASP application, can compete with nickel-base alloys at service temperatures up to 595 °C and is 100 times more corrosion-resistant than other aircraft titanium alloys. The material will be used to fabricate engine nozzles, exhaust plugs, and engine cowlings on Boeing 777s powered by Pratt & Whitney PW4000s and Rolls-Royce Trent engines—conserving about 360 lbs. per aircraft. TIMETAL 21S has potential application in chemical processing equipment, downhole equipment in oil and gas wells, biomedical implants, and electroplating fixtures.



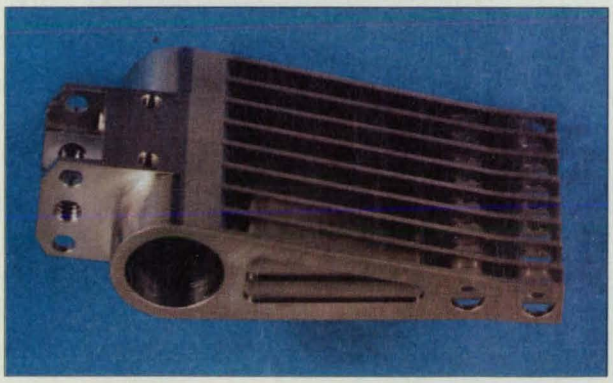
TIMETAL® 21S, a titanium alloy developed by Titanium Metal Corp., is under study by the FDA and medical supply companies for use in medical implants. A hip implant, such as the one above, offers greater durability than currently employed materials and a stiffness that more closely matches natural bone.

A recently established consortia of materials manufacturers, including Texas Instruments, Textron, Timet, Brush-Wellman, Allied Signal, and Martin Marietta, in conjunction with the NASP Joint Program Office, has focused on applying TMCs in the commercial automotive market. The consortia is designing, building, and testing an automobile engine with operation features to greatly benefit both the environment and the wallet.

"Imagine a V-8 engine that weighs less than half of a current V-8, operates at up to 20 percent increased efficiency, and reduces emissions," said West. The project is in its initial study stages, with the hope of obtaining funding from the departments of Energy, Commerce, and Transportation sometime in 1994, according to West. Commitments to commercialize the engine and its parts are being garnered from automotive companies, engineering research facilities, and parts suppliers.

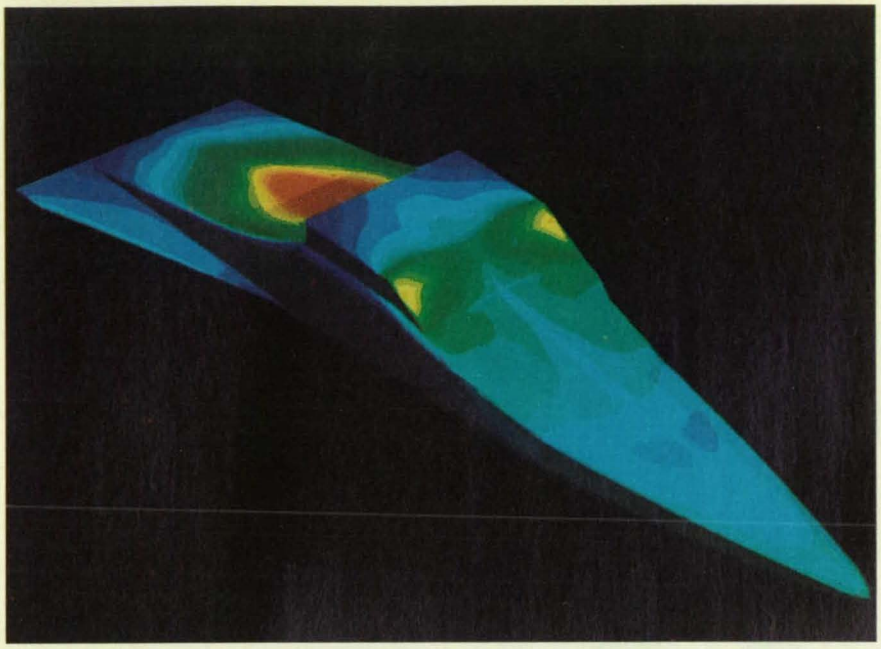
Additionally, the individual materials are attractive for use in existing engines. Replacing nickel-base alloy valves with titanium aluminide valves, for example, can result in a 50 percent weight savings as well as increased efficiency, higher operating revolutions, and increased temperature capability.

A key to application of TMCs and other metal-matrix composites is Isobaric™ cold rolling technology developed by Texas Instruments (TI) for the NASP program. The patented process offers a practical means to roll very brittle materials into high-quality, thin-gauge foils. "Programs such as NASP that require a step-function push of state-of-the-art materials technology are very rare," said Richard Delagi, a fellow at Texas Instruments. "NASP material needs challenged almost every facet of existing thermomechanical processing practice."



Brush Wellman has introduced a disk drive actuator arm made of AlBeMet™, a NASP-derived beryllium alloy. The material's high elastic modulus and low density translate into better performance, including a 15 percent reduction in access times.

Isobaric rolling has enabled Allied Signal to produce foils and honeycomb structures from a recently-developed high-temperature aluminum that offers twice the thermal capability of aircraft-grade aluminum at two thirds the weight of titanium. Other foils rolled by TI have application in automotive piston rings and catalytic converters, artificial



NASP engineers have created computational fluid dynamics (CFD) software to simulate the high speeds and flight conditions anticipated for the single-stage-to-orbit plane. Spinoff applications of the software include evaluating combustion chambers for automotive and electric power generation and improving heart and eye surgical techniques.

heart valves, corrosion-resistant pacemakers, electronics heat exchangers, piping for water desalination plants, speaker cones, and high-performance camera shutters.

Other promising NASP-related materials include AlBeMet™, a beryllium alloy developed by Brush Wellman Inc., currently used in disk drive actuator arms. Its high elastic modulus (30 million lbs/in^2) and low density (0.076 lb/in^3) translate into improved arm performance and ease of manufacturing.

Advanced Computer Simulation

The remarkable range of NASP's intended performance severely limits pre-flight components testing. Wind tunnels capable of testing systems throughout the projected flight envelope do not exist, while sub-scale models of the vehicle cannot test all areas deemed critical to success. Computational fluid dynamics (CFD), the numerical modeling of flows around an object, provides designers with tools necessary to analyze the vehicle's performance. Continued development promises multidisciplinary CFD that will enable a designer to model the vehicle and its surrounding flow in sufficient detail to create, in effect, an electronic, numerical wind tunnel.

The CFD software created for

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For More Information Circle No. 522

NASP has various industrial and medical applications. It has been applied to combustion chambers for automotive, aerospace, and electric power generation that have higher efficiencies and lower pollution rates. Recently, NASP officials brokered a strategic alliance between a premier eye surgeon and a Rockwell CFD scholar to develop and validate CFD software that will make eye surgery more effective. The program will take into account the complexity of eyeball fluid chemistry while maintaining adequate temperature and pressure in the eye during surgery. "What's needed is a complete CFD model similar to the NASP tip-to-tail simulation developed at Rockwell International Science Center," said West.

CFD also could be applied to the simulation of blood flow through the heart and arteries. One of the major problems in any surgery is the risk of requiring a repeat operation. CFD will allow the surgeon to perform the operation repeatedly in computer simulation, thereby improving predictive abilities and refining technique.

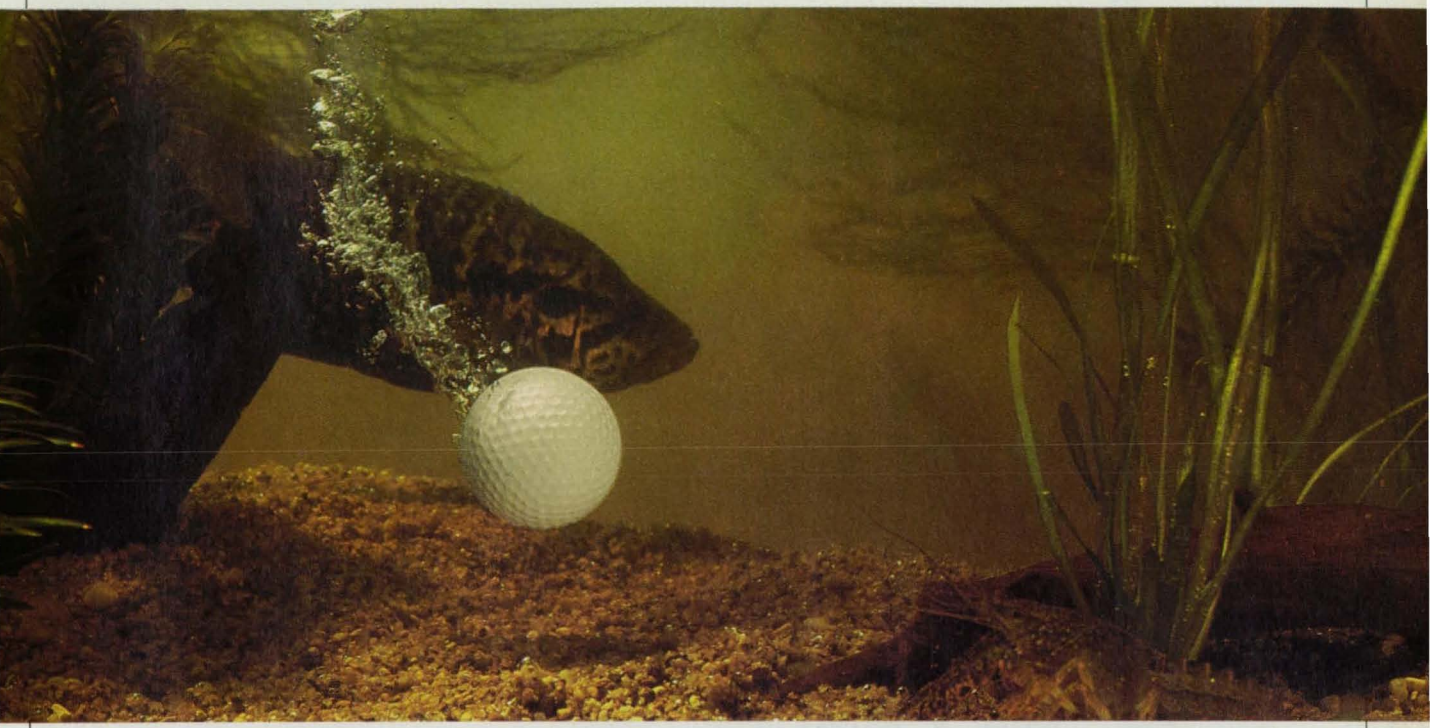
Spinoffs also are derived from NASP-related R&D in the fields of aerodynamics, propulsion, and systems integration. To achieve maximum efficiency, NASP will require exceedingly high levels of engine/airframe design integration. The intense study of vehicle-to-environment interactions is prompting advances in remote sensing and instrumentation to analyze the physical and chemical effects that affect vehicle performance. This work benefits configuration analysis, aero-instrumentation, test instrumentation, and aerothermodynamics.

NASP will surpass all other aircraft in sheer speed, capable of long-range cruising at hypersonic speeds within the atmosphere and orbital speeds up to Mach 25. Hypersonic cruise capability requires new levels of systems integration and subsystem reaction. Systems must not only sense the environment but detect incipient failures and make appropriate adjustments. Both structural sensing and software diagnostic capability could be incorporated into a wide range of industrial applications.

Further development and transfer of these technologies will depend on continued governmental support of the program. This spring, NASP faced a crossroads in program planning. "A recommended program option would insert a period of technological risk-reduction during the next five to six years," said Charles Morris, assistant director for NASP at NASA Headquarters. "This would correspond to several needs: maintaining technological momentum, responding to near-term pressures of the national budget, and providing a lower-risk design. The resulting plane would be not only lighter but cheaper as well."

Risk reduction, Morris explained, would be accomplished with flight tests of rocket-boosted, subscale test vehicles combined with complementary ground-based technology development, testing, and analysis. "Technology transfer," he said, "would remain an important part of the program." ❑

For more information on the technologies described in this article, contact Terry Kasten or Major William West at ASC/NAR, Wright Patterson Air Force Base, Ohio 45433, Tel. 513-255-3165.



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New Product Ideas

New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 24). NASA's patent-licensing program to encourage commercial development is described on page 24.

Feeder for Oxygen-Sensitive Powders

This feeder facilitates the transfer of powder in an inert atmosphere. The feeder is equipped with a sight gauge, a coupling to mate containers, an internal funnel to unload unused powder in a vacuum or inert atmosphere, and a pressure gauge.
(See page 78.)

Digital Electronic Still Camera

A prototype still camera takes images of nearly photographic quality and stores them in digital form. Designed especially for scientific use, the camera has a removable hard-disk drive that serves as electronic equivalent of photographic film.
(See page 30.)

Infrared Imaging of Flows Seeded With SF_6

A new technique for aerodynamic testing of airplane wings and other lifting surfaces uses infrared emissions from SF_6 gas to make vortical and other offsurface flows visible, continuously and nonintrusively throughout a research flight test.
(See page 34.)

Vertical-Bloch-Line Memory

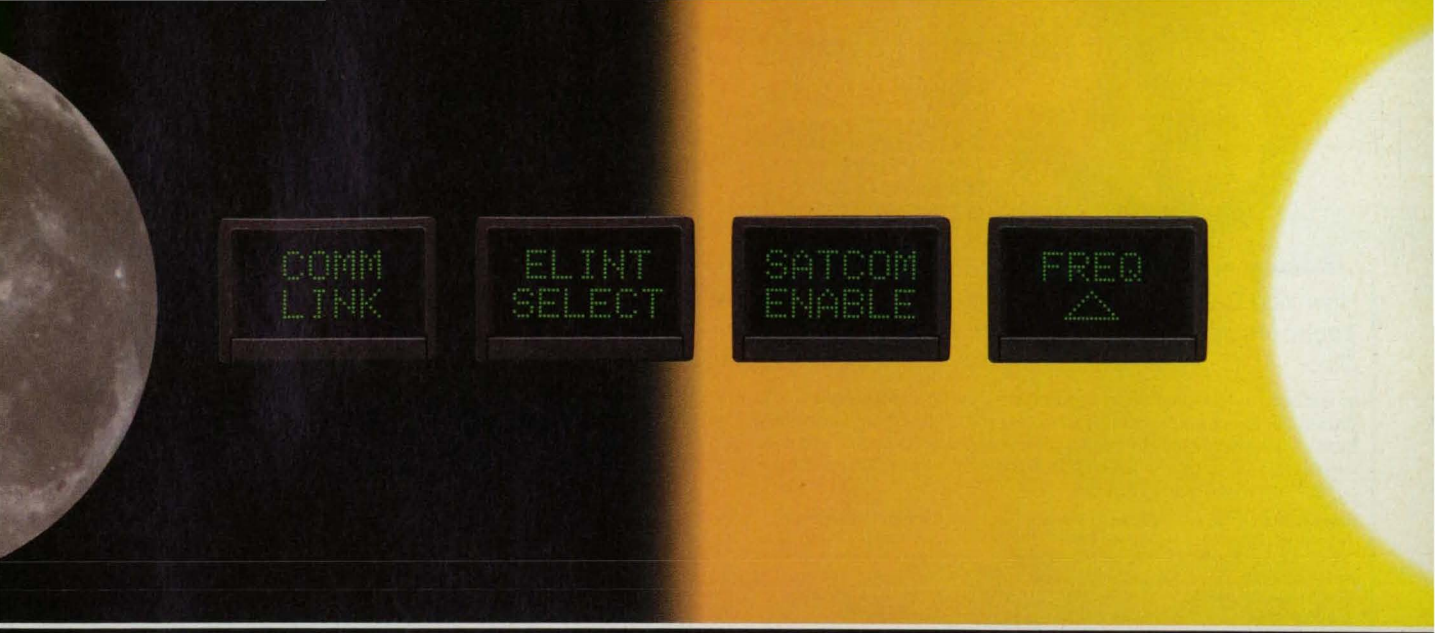
A developmental very-large-scale integrated-circuit block-access magnetic memory features resistance to ionizing radiation, potential storage density up to 1 Gb/cm^2, data rates up to 1 Gb/s, and average access times of the order of milliseconds.
(See page 42.)

Piezoelectrically Bendable Mirrors for Spatial Modulation of Light

Multiple piezoelectric actuators attached to the back of these mirrors apply controlled local bends to alter the shapes of the reflecting surfaces. Potential applications are in spatial light modulation in optical computers, compensation for atmospheric distortions in telescopes, and other uses requiring controllable changes in wave fronts.
(See page 52.)

Silicon-Etalon Fiber-Optic Temperature Sensor

A developmental sensor consists of a silicon Fabry–Perot etalon attached to the end of an optical fiber. Because sensor output is encoded in the ratio of intensities at two different wavelengths, temperature readings are not degraded much by changes in the transmittance of the fiber-optic link.
(See page 54.)



The NVIS-Sunlight Readable Electro-Optical Display System.

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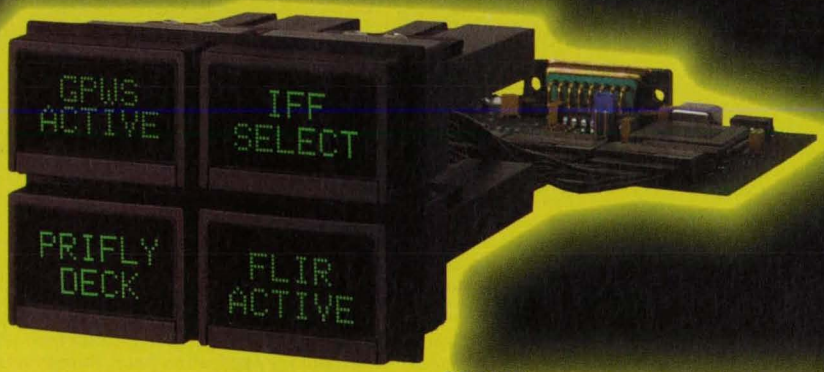

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We've outlined below NASA's Technology Transfer Network—named the participants, described their services, and listed the individuals you can contact for more information relating to your specific needs. We encourage you to make use of the information, access, and applications services offered.

How You Can Access Technology Transfer Services At NASA Field Centers:

Technology Utilization Officers & Patent Counsels—Each NASA Field Center has a Technology Utilization Officer (TUO) and a Patent Counsel to facilitate technology transfer between NASA and the private sector.

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP). If a TSP is not available, you can contact the Technology Utilization Officer at the NASA Field Center that sponsored the research. He can arrange for assistance in applying the technology by putting you in touch with the people who developed it. If you want information about the patent status of a technology or are interested in licensing a NASA invention, contact the Patent Counsel at the NASA Field Center that sponsored the research. Refer to the NASA reference number at the end of the Tech Brief.

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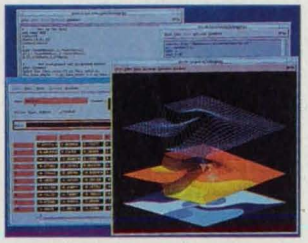

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For More Information Circle No. 494

Advanced Computed-Tomography Inspection System

Three x-ray sources and adjustable scan geometry give this system unprecedented versatility.

Marshall Space Flight Center, Alabama

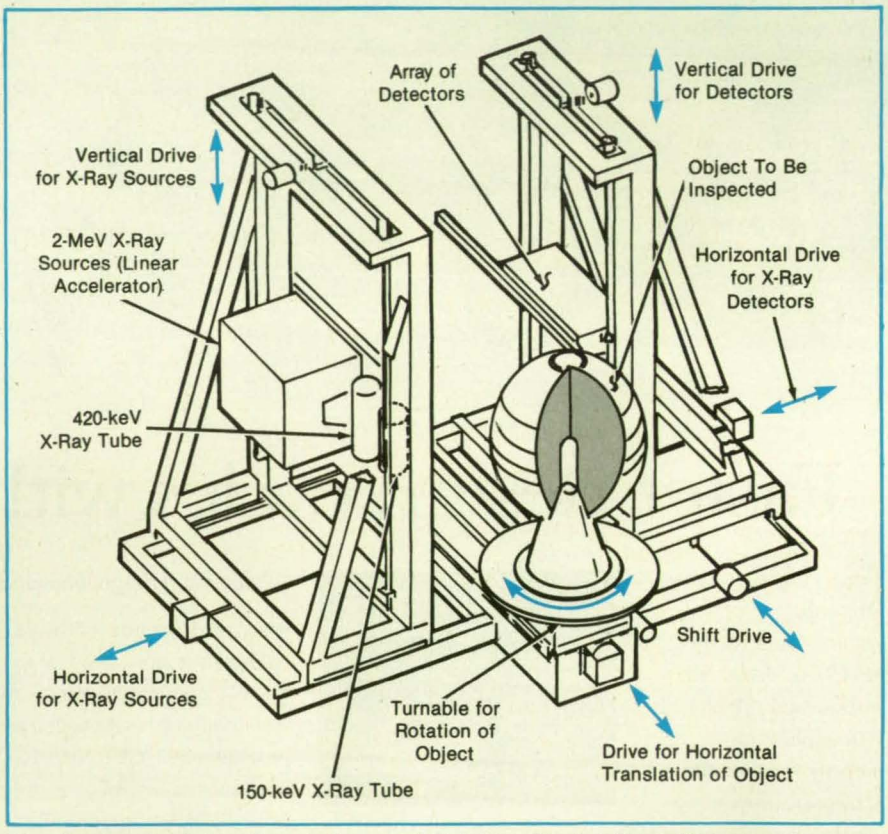
The Advanced Computed Tomography Inspection System (ACTIS) is a computed-tomography x-ray apparatus that reveals the internal structures of objects in a wide range of sizes and materials. The system can be used in such diverse applications as development of new materials, refinement of manufacturing processes, and inspection of components.

The density and spatial and temporal resolution of the x-ray scanner in the ACTIS can be optimized to suit the application. The ACTIS includes three x-ray sources, with maximum potential photon energies of 150 keV, 420 keV, and 2 MeV, respectively. By selection of one of these sources for a particular application, one can scan a small, low-density object as effectively as one can scan a large, dense one.

An object to be inspected is mounted in a gantry, which contains mechanisms that rotate the object and translate it horizontally past the x-ray sources and solid-state detectors. The sources and detectors are mounted on opposite towers of the gantry (see figure). Sources and detectors are translated vertically in synchronism during vertical scans.

An operator loads the part to be scanned and exerts overall control over the sources, detectors, and scanning motions via a console, which serves as an interface with a host computer. The host computer, in turn, manages the details of operation of the resources of the system for the operator, adjusting translation and rotation speeds and x-ray-source voltages and collecting data, among other functions.

For scanning such dense and high-atomic-number materials as glass-reinforced plastics, or for scanning large objects, the preferred x-ray source is a linear accelerator. The maximum photon energy produced by this device can be set at either 1 or 2 MeV. For smaller, less-dense objects, the 150- or the 420-keV x-ray tube is selected. The 150-keV x-ray tube produces a narrower beam and therefore resolves finer details; wires separated by less than 0.5 mm can be distinguished. The 150-keV tube is especially effective for thin-walled objects. The 420-keV tube can be set to a continuous range of voltages and either of two beam diameters.



The **Gantry Contains Translation and Rotation Mechanisms** that scan the x-ray beam through the object to be inspected. The distance between source and detector towers can be varied to suit the object.

The detectors are placed in a semicircular array of 1,024 pixels. The outputs of the detectors are collected by a data-acquisition subsystem, which feeds the raw image data to an image processor that operates at a maximum rate of 200 million instructions per second. The image processor computes the tomographic images, which are then stored on a magnetic disk for immediate display and on an optical disk or magnetic tape for later retrieval.

The image is displayed on a high-resolution monochrome video monitor. The upper area of the video display (composed of 1,024 by 1,024 pixels) shows the computed tomographic image at a level of detail selected by the operator; for example, the operator can zoom in on a region of special interest. The lower right part of the display presents alphanumeric information about the system and statistics on the region of interest. The lower left part of the display retains the original image for reference when the operator commands a zoom view.

The ACTIS can scan objects up to 127 cm wide and 230 cm high, weighing up to 1,000 kg. Its spatial resolution ranges from 5.1 to 16.2 line-pairs per centimeter, the exact value depending on the selection of the source and the distance from the source to the detector. Scanning an object and reconstruction of the image takes from 2 to 11 minutes, depending on the resolution.

This work was done by Lowell D. Harris, Nand K. Gupta, Charles R. Smith, Richard T. Bernardi, John F. Moore, and Lisa Hediger for **Marshall Space Flight Center**. *For further information, Circle 13 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-27278.

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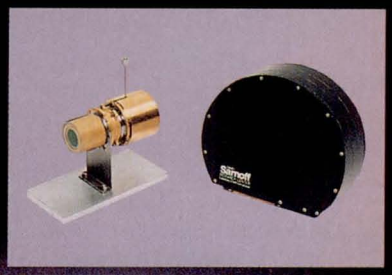

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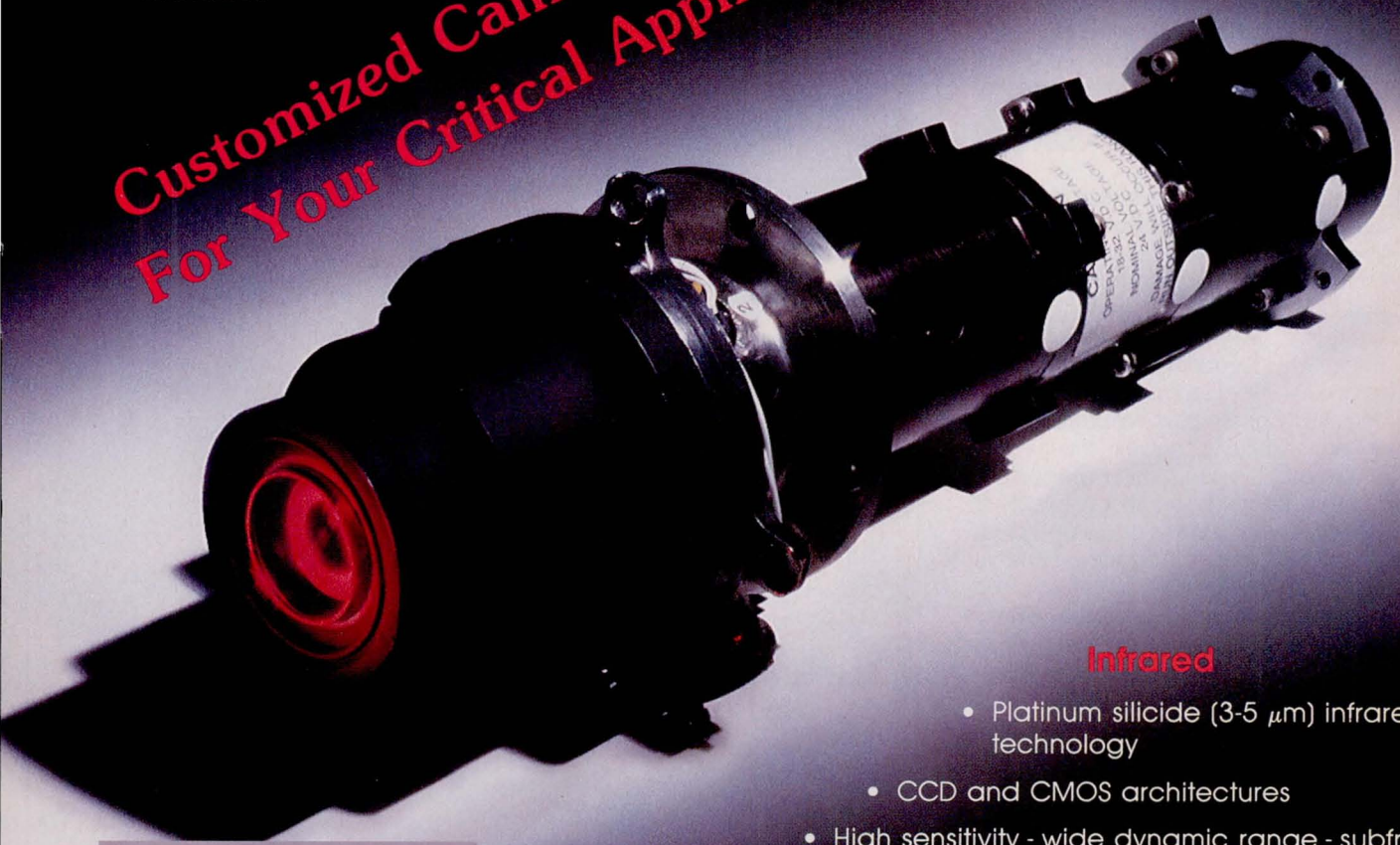

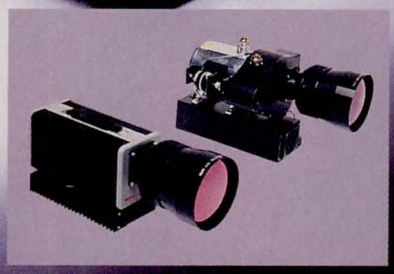

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For More Information Circle No. 406

Algorithms for Segmentation of Complex-Amplitude SAR Data

The physical basis of speckle is taken into account.

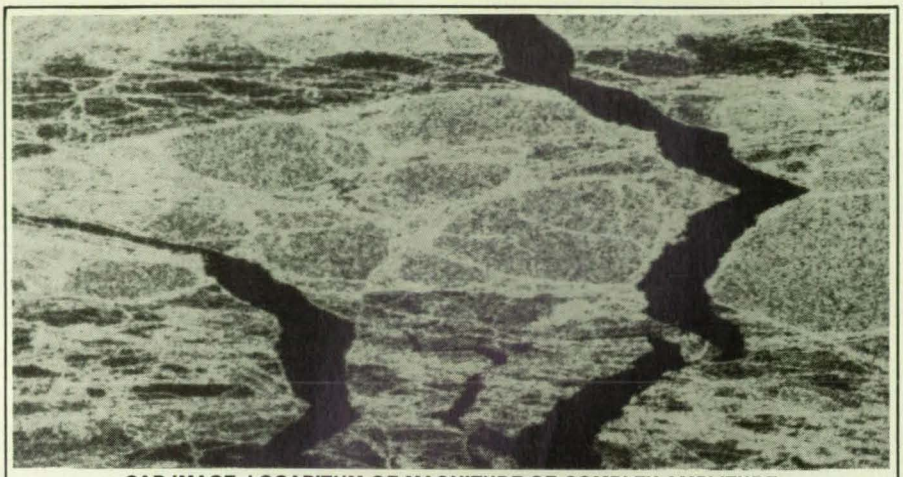
NASA's Jet Propulsion Laboratory, Pasadena, California

Several algorithms implement an improved method of segmenting highly speckled, high-resolution, complex-amplitude synthetic-aperture-radar (SAR) digitized images into regions, within each of which backscattering characteristics are similar or homogeneous from place to place. Typically, each region represents a different type of terrain, terrain cover, or other surface; e.g., forest, agricultural land, sea ice, or water. The principal difference between this method and older methods of segmentation is that it is based on two mathematical models: one for the speckled complex amplitudes, the other for labeling the regions.

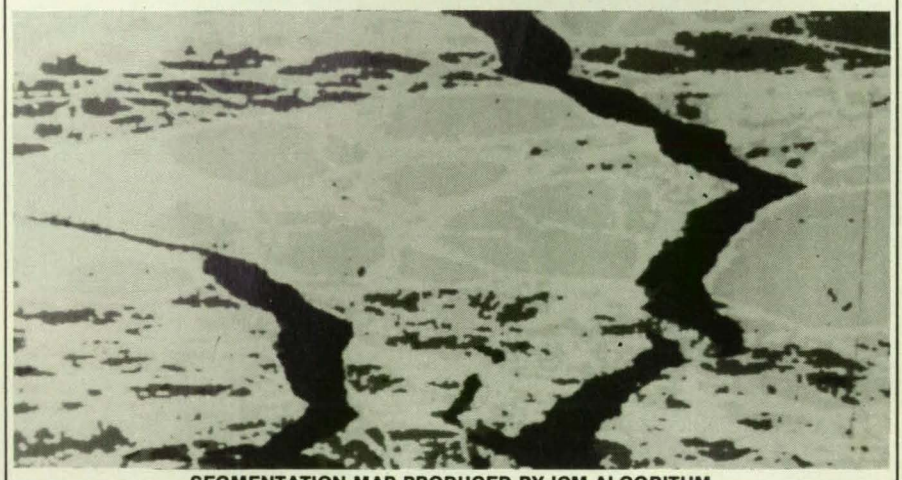
Speckle is a form of noise that manifests itself in a granular appearance of an SAR image, and it degrades radiometric resolution. It is caused by interferences among coherent radar returns from multiple scatterers within each affected resolution element. Previous methods of coping with speckle have not taken account of the full complexity of the physical processes of coherent imaging, but experience has shown that the statistics of speckle are highly dependent on the characteristics of the SAR equipment and on the SAR processing parameters. Accordingly, in this method, speckle is mathematically modeled on the basis of the physics of the SAR imaging and image-processing subsystems. The model accounts for the impulse-response function of the SAR equipment, the backscattering characteristics of various targets, effects of uncontrolled changes (caused by pitching, rolling, and yawing of the airplane carrying the SAR) in aim of the radar antenna, and the use of side-lobe-weighting filters in the SAR processor.

To complete the representation of the complex-amplitude SAR image data, the model of speckle is combined with a Markov-random-field probabilistic model of the distribution of region labels across the imaged scene. On the basis of the resulting composite model and by use of Bayes' theorem, an optimal labeling of regions in the image can then be defined by maximizing the posterior density of the labels.

To obtain an exact global solution of this optimization problem, one would have to use a computationally demanding algorithm; for example, one based on the simulated-annealing technique. Instead, this method provides for approximate, deterministic solution by two alternative algorithms that almost always converge to



SAR IMAGE: LOGARITHM OF MAGNITUDE OF COMPLEX AMPLITUDE



SEGMENTATION MAP PRODUCED BY ICM ALGORITHM

SEGMENTATION MAP PRODUCED BY MPM ALGORITHM

An **SAR Image of Ice** on the surface of the Beaufort Sea was segmented by the ICM and MPM algorithms. The accuracy of segmentation by the ICM algorithm was found to be better than that of prior segmentation algorithms. The MPM map is similar to the ICM map except in some details.

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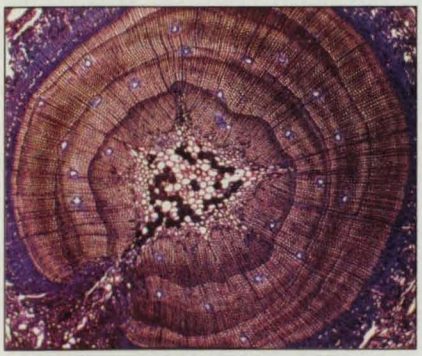

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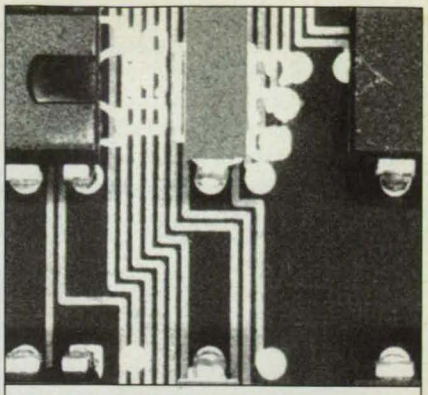

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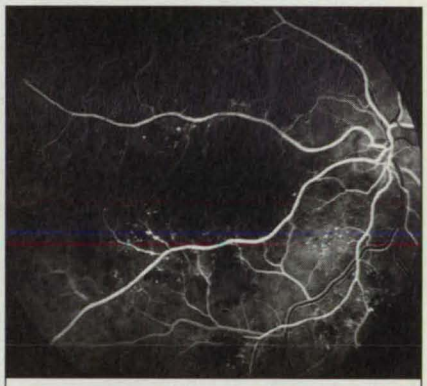

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For More Information Circle No. 472

local minimums: one is the Iterative Conditional Modes (ICM) algorithm, which locally maximizes the posterior probability density of the region labels; the other is the Maximum Posterior Marginal (MPM) algorithm, which maximizes the posterior marginal density of the region labels at each pixel location. The ICM algorithm optimizes the reconstruction of the underlying scene. The MPM algorithm minimizes the expected number of misclassified pixels — possibly better in remote sensing of natural scenes. The method has been tested with simulated and real SAR imagery (see figure) and found to be practical.

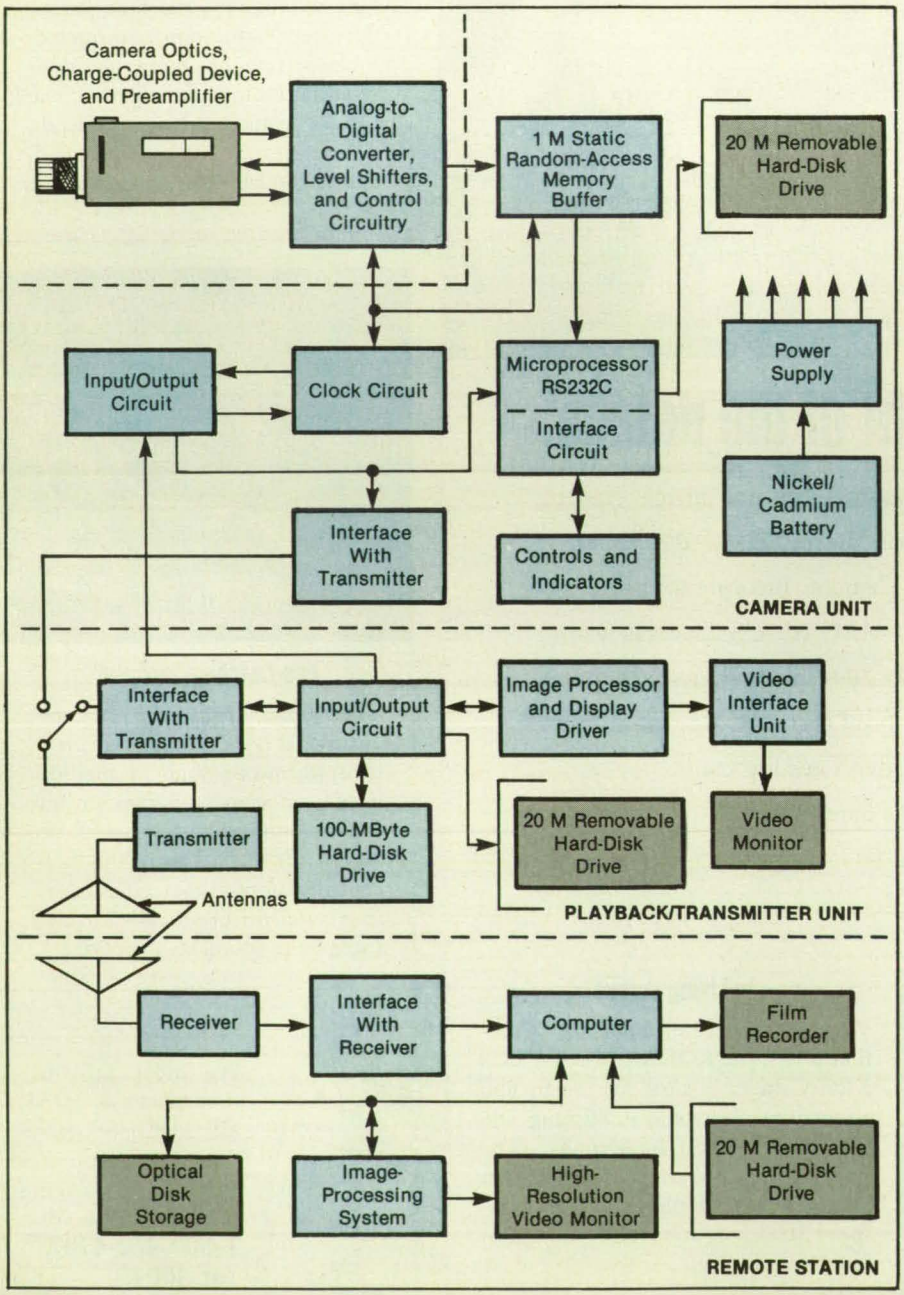
This work was done by Eric J. M. Rignot and Ramalingam Chellappa of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 3 on the TSP Request Card.*
NPO-18524

Digital Electronic Still Camera

Images can be viewed, analyzed, or transmitted quickly.

Lyndon B. Johnson Space Center, Houston, Texas

The prototype digital electronic still camera takes images of nearly photographic quality and stores them in digital form. The camera is a portable, hand-held, battery-powered unit that is designed especially for scientific use. Unlike in film photography, the images produced by this camera can be viewed and/or transmitted to a remote station immediately. In comparison with analog video cameras, this camera produces images of higher quality. Unlike in both film photography and analog video, the images produced by this camera can be analyzed digitally with relative ease because there is no need for intermediate processing to convert the output of the camera to digital form.



The **Digital Electronic Still Camera** is part of an electronic recording, processing, transmitting, and displaying system. The removable hard-disk drive in the camera serves as the digital electronic equivalent of photographic film.

The camera is used in conjuction with a playback unit that also serves as a transmitting unit if the images are to be sent to the remote station. The remote station is equipped to store, process, and display the images (see figure). The digital image data could be encoded with an error-correcting code at the playback/transmitting unit for error-free trasmission to the remote station.

The prototype digital electronic still camera is a modified commercial film camera, in which the film cartridge is replaced by an imaging charge-coupled device and the associated electronics. The electronic camera is operated in the manner of the film camera and accepts all the lenses, flash attachments, and other film-camera accessories. The images are stored in a removable hard-disk drive, which thus serves as the digital electronic equivalent of the film. The hard-disk drive is removed from the camera and plugged into the playback/transmitting unit for viewing, local processing, or transmission of the image.

The camera can be programmed to produce an image in any of three resolution/color formats: 1K × 1K monochrome, 2K × 2K monochrome, or 1K × 1K color. There is no compromise of resolution in any of the three color planes, and there are plans to upgrade to a 4K × 4K format. The dynamic range of the camera is about 60 dB. The image is digitized to 8 bits. The image can be focused manually or automatically. The exposure can be adjusted manually or automatically, with spot or center-weighted metering. The date and time are recorded automatically on each image. There is even a provision for recording of latitude and longitude (supplied by ancillary equipment) or of data supplied by the operator.

This work was done by Samuel D. Holland and Herbert D. Yeates for **Johnson Space Center**. *For further information, Circle 9 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center [see page 24]. Refer to MSC-21797.

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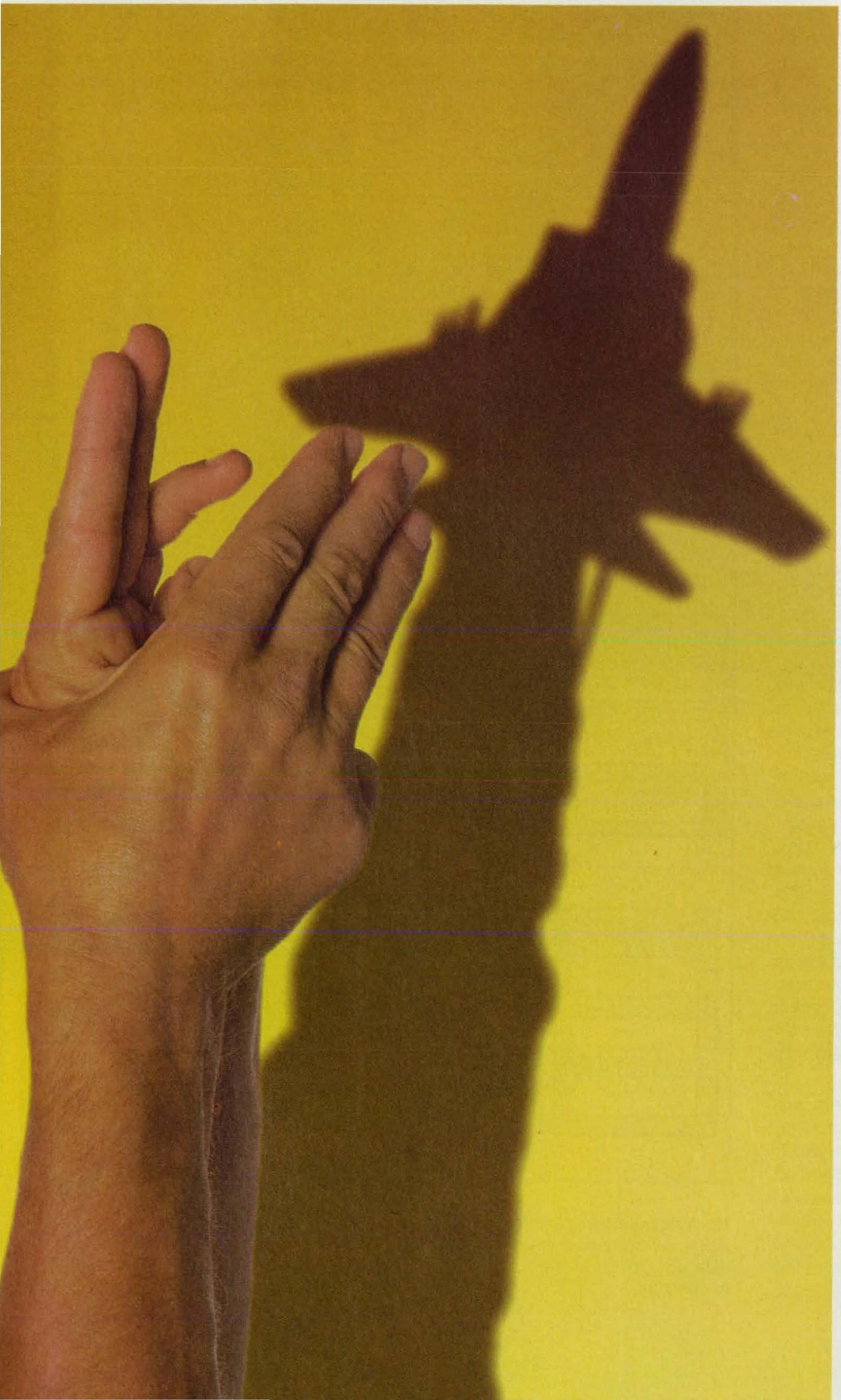

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For More Information

Circle No. 430

Mapping Wildfires in Nearly Real Time

An airborne infrared-sensing system yields timely information.

NASA's Jet Propulsion Laboratory, Pasadena, California

An airborne infrared-sensing system (see figure) supplies information to firefighters about wild-land fires in nearly real time. The system, called Firefly, reveals the position of fires and approximate thermal intensities of regions within fires. The firefighters can use the information to manage and suppress the fires.

Heretofore, current infrared systems have captured fire data on an image recorder, which entails the usual time-consuming processing of film. Photographs are not available until an airplane returns to the ground. Furthermore, the photographs must be interpreted. The information has typically been as much as 6 h old before firefighters could respond to it.

In the Firefly system, an infrared line-scanning detector on an airplane views the fire scene. The pilot flies the airplane over and/or around the fire so that the detector can scan the entire area. A crewmember observes the raw data from the instrumentation and relays information to the pilot, enabling the pilot to optimize the flightpath. The crewmember can annotate the raw data if desired.

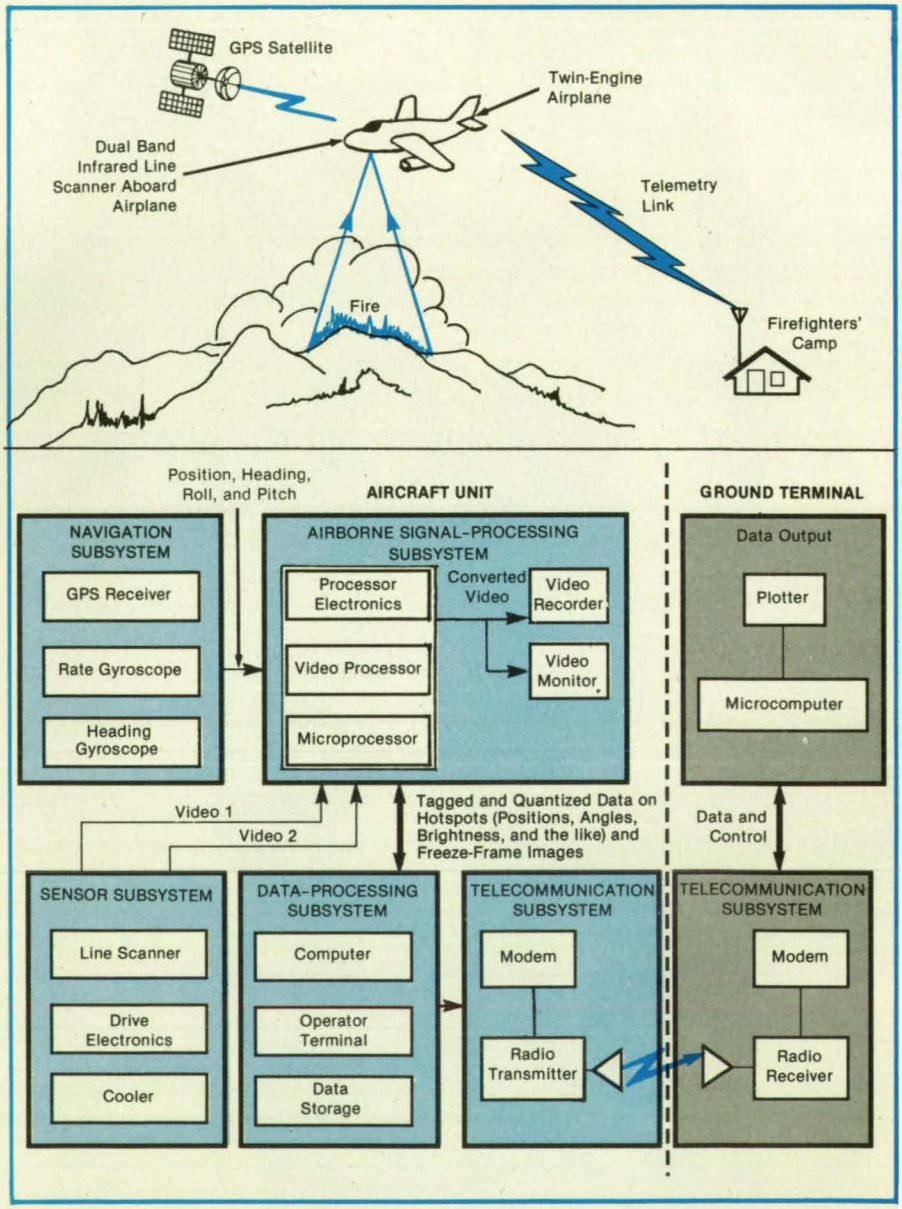
An onboard computer processes the infrared image data, position data is obtained from satellites in the Global Positioning System (GPS), and terrain-elevation data from the U.S. Geological Survey. From all these data, the computer prepares a detailed map that is transmitted digitally to firefighters' camps, where the map is printed, either in color or black and white. Unlike in aerial photography, interpretation is unnecessary: the relevant information is automatically printed on the map. The entire process, from air survey to printout, takes less than 30 min. Each pixel in the map represents an area about 25 ft (about 8 m) square. Locations of features on the map are accurate within 500 ft (about 150 m) of their true positions.

The Firefly system can detect a fire as small as that in a small portable stove from an altitude of 10,000 ft (about 3,000 m). It can map fires that cover areas larger than 10,000 acres (about 4,000 hectares) in as little as 10 minutes.

The components of the system are mostly commercially available products. The system has a modular design, which facilitates upgrading as more-advanced components become available. The infrared detector gathers data in two wavelength bands. The data are first processed separately, then combined to create the map. Dual-wavelength sensing is used to meet the small-fire sensitivity requirement. Hotspots are identified by infrared spectral characteristics, specifically by the difference between intensities of the same pixel in the two wavelength bands. If the difference in a given pixel is characteristic of a high temperature, then a fire is identified at the corresponding location on the ground.

The Firefly system could also be used for other purposes with minor modifications. For example, it can be used to spot losses of heat in urban areas and to map disease and pest infestation in vegetation.

This work was done by Joseph D. Nichols, Gary S. Parks, Richard F. Denning, Anthony C. Ibbott, Kenneth C. Scott, William J. Sleigh, and Jeffrey M. Voss of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 57 on the TSP Request Card.*
NPO-18666



The **Airborne Infrared-Sensing System** flies over a wildfire as an infrared detector in the system and a navigation subsystem generate data to be transmitted to a firefighters' camp. There, data are plotted in the form of a map of the fire, including approximate variations of temperature.

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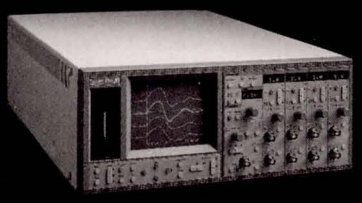

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For More Information Circle No. 523

Infrared Imaging of Flows Seeded With SF_6

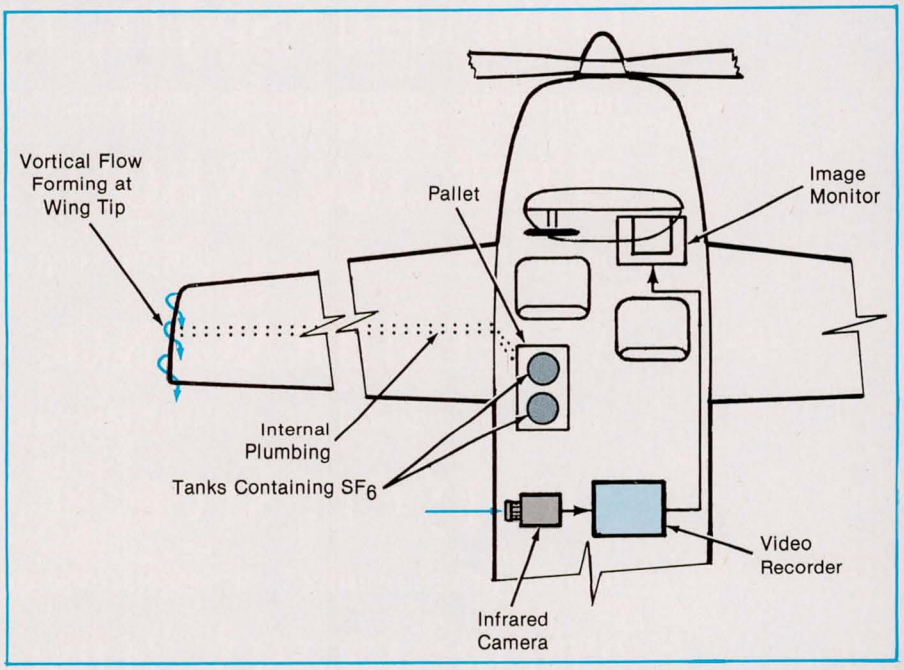
A novel technique enables repeated measurements of flow patterns during flight.

Langley Research Center, Hampton, Virginia

Qualitative off-surface flow-visualization measurements play an important role in flight and wind-tunnel aerodynamic testing of airplane wings and other lifting surfaces. Flow visualization can help provide a complete understanding of the formation, locations, sizes, and intensities of vortices. The technique used heretofore to study vorticity in flight is smoke-flow visualization, in which either a smoke bomb of short duration or a large kerosene-fired smoke generator is used. A new technique that has been developed at NASA Langley Research Center overcomes the limitations of these techniques, providing the capability to make vortical and other offsurface flows visible, continuously and nonintrusively, throughout a research flight test.

In the new technique, the vortex or other off-surface flow phenomenon is made visible by seeding the flow with a substance that is visible in the infrared and observing the flow through an infrared imaging system. Wing-tip vorticity was selected as the off-surface aerodynamic phenomenon to be made visible in a demonstration of this technique. Wing-tip vorticity is a well-known, strong, induced drag effect that occurs when the difference between the pressures on the upper and lower surfaces of the wing gives rise to a flow around the tip of the wing.

In this demonstration, the wing-tip vortex on a NASA research airplane in flight was seeded with sulfur hexafluoride (see figure), a gas that emits and absorbs radiation strongly at wavelengths from 8 to 12 μm. The infrared imager used in the test operated in this wavelength range. It included a single mercury cadmium telluride detector, which was cooled by liquid nitrogen to improve its thermal sensitivity. The field of view of the infrared-imaging optics was focused on the detector, and galvanometers provided the horizontal and vertical scanning of the field of view across the detector. The output of the system was a raster-scan video signal that was recorded on a video cassette recorder. The recorded video data were then processed by use of standard image-processing equipment.



Wing-Tip Vorticity was studied in flight by observing infrared emissions from SF_6 gas entrained in the wing-tip flow.

The system can make vortical flows visible throughout all altitude and speed ranges of all subsonic aircraft. It may also be useful for transonic and supersonic speeds. Although its primary application is in the testing of aircraft in flight, it might also prove useful in testing fast land vehicles and structures or devices subject to strong winds.

This work was done by Gregory S. Manuel, Kamran Daryabeigi, and David W. Alderfer of **Langley Research Center** *and Clifford J. Obara of Lockheed Engineering and Science Co., Inc. For further information, Circle 84 on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 24]. Refer to LAR-14568.

Constructing an Image From Nonuniform-Scan Data

An iterative algorithm constructs a maximally likely image by a maximum-correlation method.

NASA's Jet Propulsion Laboratory, Pasadena, California

An algorithm performs the maximum-likelihood construction of the image of a scene scanned nonuniformly by a linear array of photodetectors, the responses of which are unequal. The algorithm was developed to postprocess data acquired by the scanning telescope aboard the Infrared Astronomical Satellite (IRAS) in the year 1983, but is also adaptable to the generation of high-resolution imagery from data acquired in other nonuniform-scanning applications (see figure). The achievable resolution is not limited by the finite size of the detectors, and it increases with the density of the scans. In principle, with sufficiently dense scans, one could even obtain resolution beyond the diffraction limit of the imaging optics.

The algorithm constructs an image that is maximally likely in a statistical sense. It takes account of the spatial response (blurring) functions of the detectors; the partial overlapping of scan lines; and the temporal correlation, caused by low-pass filtering in the detector circuitry, between measurements by the same detector at successive sampling times. The spatial and temporal correlations can be characterized, respectively, by (1) a mean minimum correlation length related to the re-

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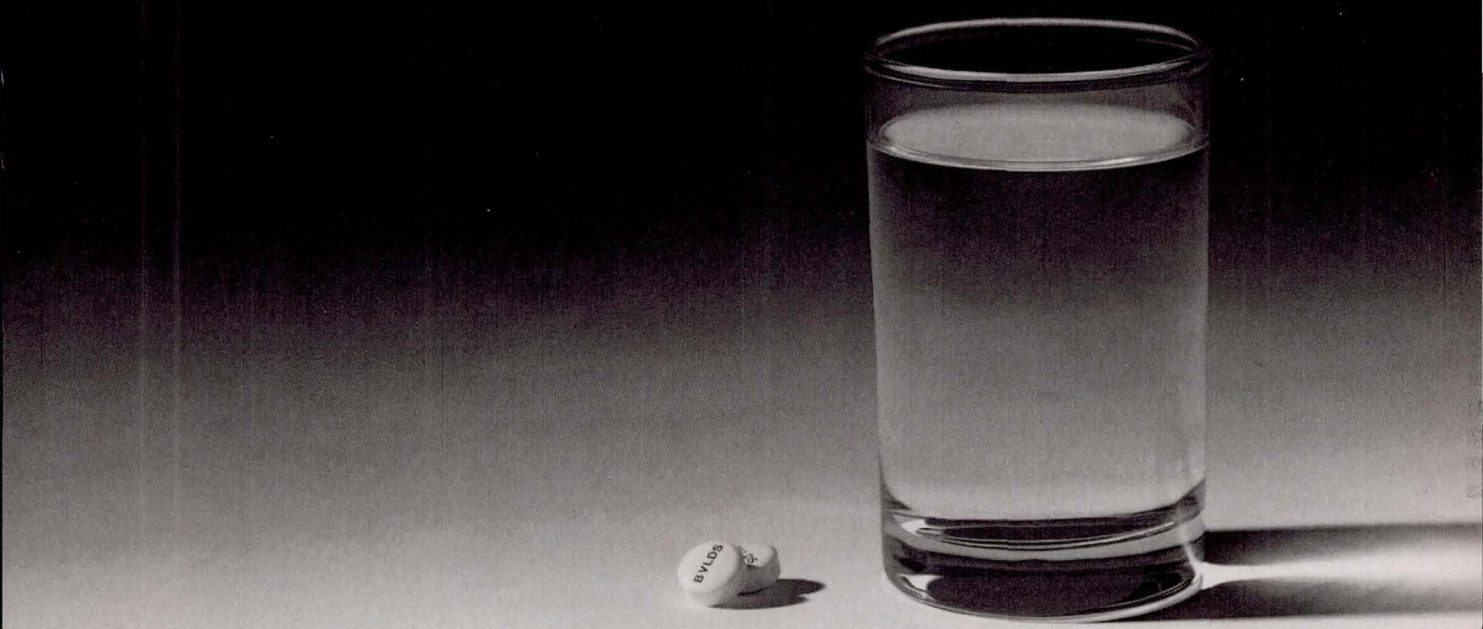

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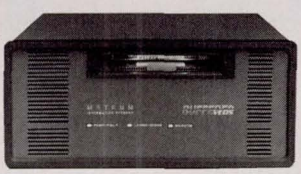

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sponse functions of the detectors and (2) the inverse exponential of the ratio between the low-pass cutoff and sampling frequencies. The algorithm is said to implement a maximum-correlation method because it constructs the image in a way that maintains the maximum correlation among picture elements consistent with the measurements and the response functions of the detectors.

One of the main differences between this and other linear and nonlinear resolution-enhancing algorithms is that there is no initial input low-resolution image. However, inasmuch as this algorithm constructs the image recursively, there are successively sharper intermediate images; that is, images in which picture elements separated by more than the minimum correlation length become increasingly decorrelated on subsequent iterations.

In essence, the algorithm estimates values of brightness in the scanned picture elements through the spatial and temporal response functions and compares the resulting computed detector outputs with the real ones. Correction factors weighted by the appropriate detector-response functions are computed and used to create a correction-factor image and a correction-factor-variance image. The improved estimate of the image is obtained by point-by-point multiplication of the current image by the correction-factor image. The mean correction factor for each picture element converges to unity. The rate of convergence depends on the mean correlation length, the signal-to-noise ratio, and the size of a picture element. This iterative process starts with an initial featureless image of uniform brightness and is terminated when a χ^2 statistical test indicates that the real photodetector responses and the responses computed by use of the estimated image have converged within some small random errors.

Figure 2 shows the result of processing the data from Figure 1. The effective resolution of the final image is about 36 arcsec, which is almost a factor of 10 smaller than the size of the detectors.

This work was done by Hartmut H. Aumann, John W. Fowler, and Michael Melnyk of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 80 on the TSP Request Card.*
NPO-18234

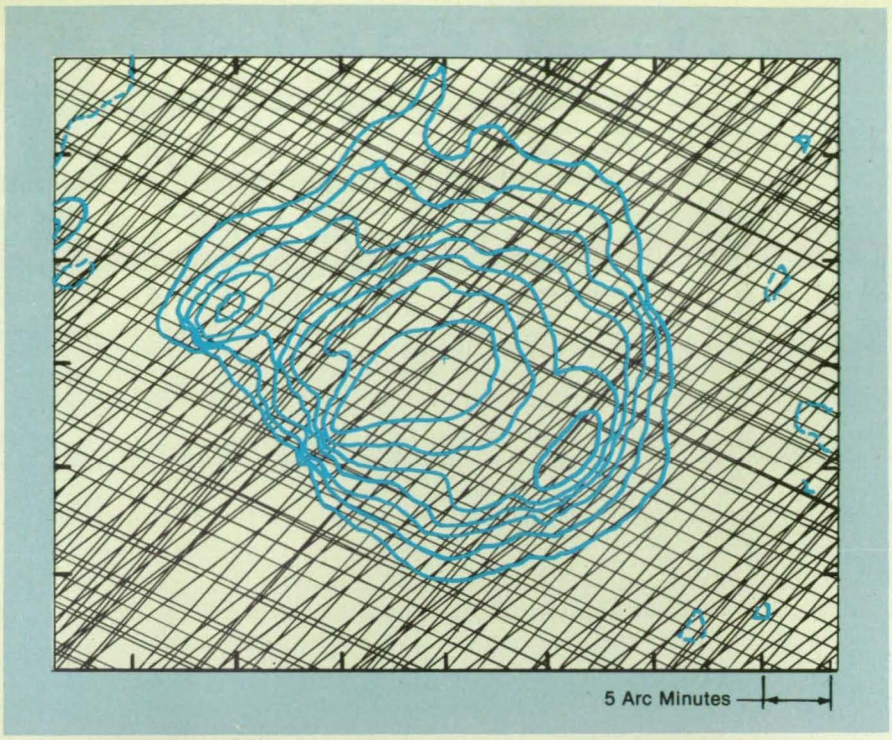

Figure 1. **Nonuniformly Distributed Scan Lines** are superimposed on a contour image of the galaxy M101 (NGC 5457) in infrared light at a wavelength of 60 μm. The sizes of the detectors are comparable to the distance between the 5-arc-minute fiducial marks on the image plane.

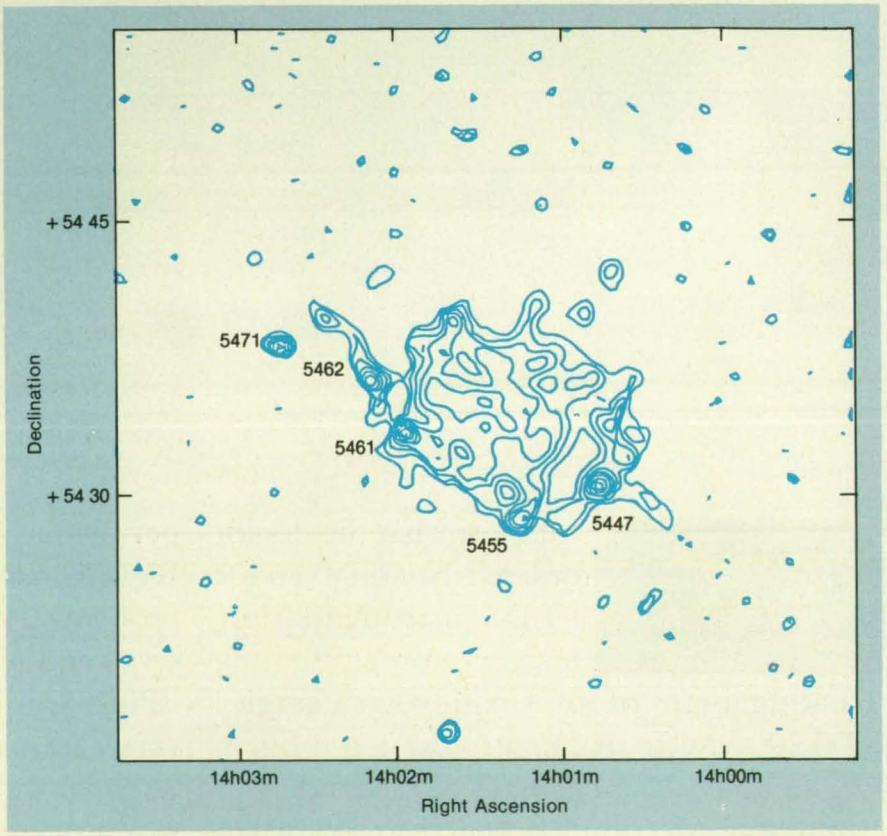

Figure 2. **Final Image** of IRAS survey data of the M101 region at 60 μm, after 60 iterations with the MCM algorithm. A dozen peaks can be identified with the location of HII regions previously identified from Hα emission. Based on the brightes HII regions, identified in the map, the effective resolution of the image is 36 arcsec.

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For More Information Circle No. 397

Photographic System Makes Path of Vortex Visible

A stroboscope is synchronized with the generation of the vortex.

Langley Research Center, Hampton, Virginia

A system that makes rapid flows visible was developed to record the track followed by a ring vortex when it encounters an object near its path. This system is being used at NASA Langley Research Center to record the path after a vortex is "fired" from a vortex generator at speeds of up to 150 ft/s (45.7 m/s).

The optical setup (see Figure 1) is a Schlieren setup of 30 in. (76.2 cm) focal length, 6 in. (15.2 cm) diameter, and a standard Z-configuration mirror arrangement. The source of light is a low-pressure xenon short-arc lamp capable of flashing at rates up to 10 kHz with a flash duration of approximately 0.5 μs. A cylinder 1 in. (2.54 cm) in diameter is placed at any of a number of different locations near the expected path of the vortex.

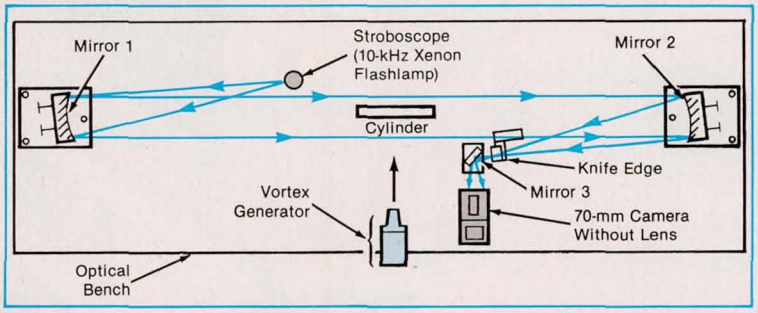

Figure 1. This **Schlieren Optical Setup** includes a standard Z-configuration mirror arrangement and a pulsed, synchronized source of light.

Sound pressure waves, produced when the vortex generator is triggered, are detected by a microphone, signaling the presence of a vortex. Inasmuch as the vortex travels more slowly than the sound pressure wave does, the triggering of the flashlamp must be delayed. By triggering the flashlamp at the proper time, the path of the vortex can be made visible just as it passes over the cylinder.

A 70-mm camera, without lens, is used to record up to 20 multiple exposures on the same frame to show the path of the vortex. From this sequence, its velocity can be determined. From the differences between the velocities determined in sequential pairs of exposures, the acceleration can be determined.

Figure 2 is a photograph from a typical test. This system has proven to be valuable in determining the position, velocity, and acceleration of the vortex as it passes over and interacts with an object in its path. The Schlieren photographs were used to verify proper operation of the vortex generator as well as the path of the vortex.

This work was done by Stephen B. Jones of **Langley Research Center** *and Greg Szczepkowsky of George Washington University. No further documentation is available. LAR-14563*

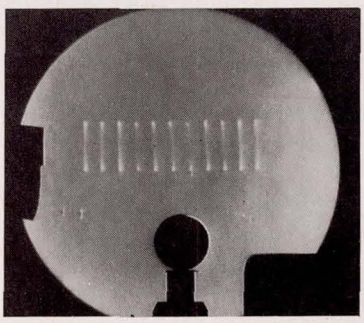

Figure 2. The **Vertical Lines** are side views of a ring vortex (at different positions) made visible by the Schlieren apparatus.

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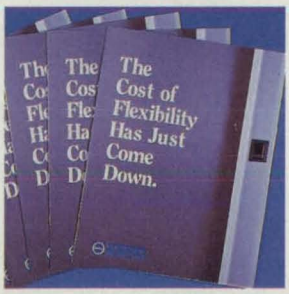

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For More Information Circle No. 488

Gaussian-Beam/Physical-Optics Design of Beam Waveguide

The Gaussian-beam and physical-optics techniques are applied iteratively.

NASA's Jet Propulsion Laboratory, Pasadena, California

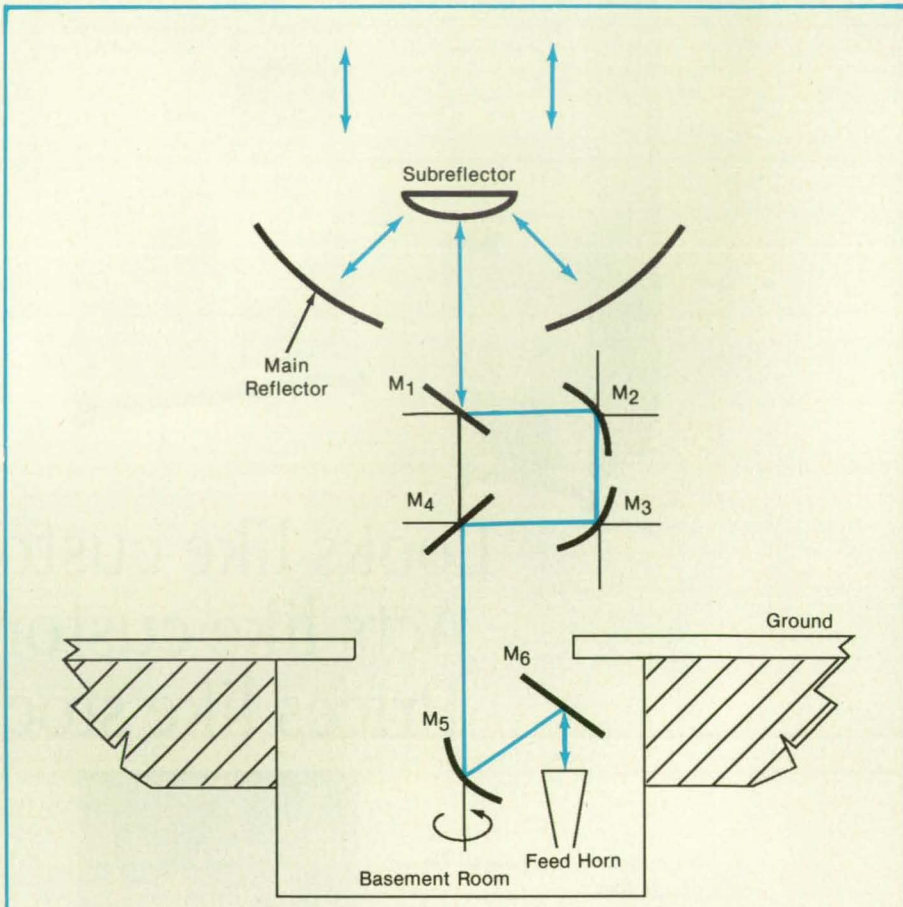
In an iterative method of designing a wideband beam-waveguide feed for a paraboloidal-reflector antenna, the Gaussian-beam approximation is alternated with a more nearly exact physical-optics analysis of diffraction. The method is particularly useful for designing beam-waveguide reflectors or mirrors that are required to have diameters $\lesssim 30$ wavelengths at one or more intended operating frequencies.

The geometrical-optics approximation can be used to design reflectors that have diameters $\gtrsim 50$ wavelengths and edge tapers of -20 dB or less (edge taper is the ratio between the magnitude of the Poynting vector at the edge of a reflector and the magnitude of the Poynting vector on the nominal axis of the radiation beam at the reflector surface). The Gaussian beam mode is an approximate solution of the wave equation; it describes a beam of radiation that is unguided but effectively confined near an optical axis. The major advantage of the Gaussian approximation is its simplicity and ease of implementation with negligible computing time. However, the Gaussian approximation can become unacceptably inaccurate at diameters $\lesssim 30$ wavelengths: this gives rise to the need for the present iterative method.

The beam waveguide of a typical large paraboloidal-reflector antenna consists of a subreflector, a microwave feed horn, and a set of intermediate small flat and curved mirrors that guide the radiation from the feed horn to the subreflector (see figure). The basic design goal is to make the radius of curvature (R) of the wave front at the subreflector and the diameter (D) of the subreflector constant over the design frequency range, while maintaining acceptably low spillover loss at all mirrors (including the subreflector).

The input parameters are the operating frequencies, the diameters of the curved mirrors (the flat mirrors are all assumed to be sufficiently large), and the maximum allowable spillover loss or edge taper at each mirror. The other parameters shown in the figure are determined during the iterative design procedure, which consists of the following steps:

1. By use of the geometrical optical approximation, design a beam waveguide that roughly fits the antenna structure and satisfies other basic design requirements. The parameters of this design serve as the initial values for the iteration.
2. Using the zero-order Gaussian mode starting from the feed horn and proceeding through the intermediate mirrors to the subreflector, calculate D and R. The unknown design parameters are iterated until the values of R and D at all intended operating frequencies lie



The **Beam Waveguide** includes curved and straight reflectors that guide radiation from the feed horn to the subreflector. For the iterative design calculations, the curved mirrors can be mathematically modeled as thin lenses. Each distance L_i is the combined length of two straight-line segments that intersect at one of the flat mirrors.

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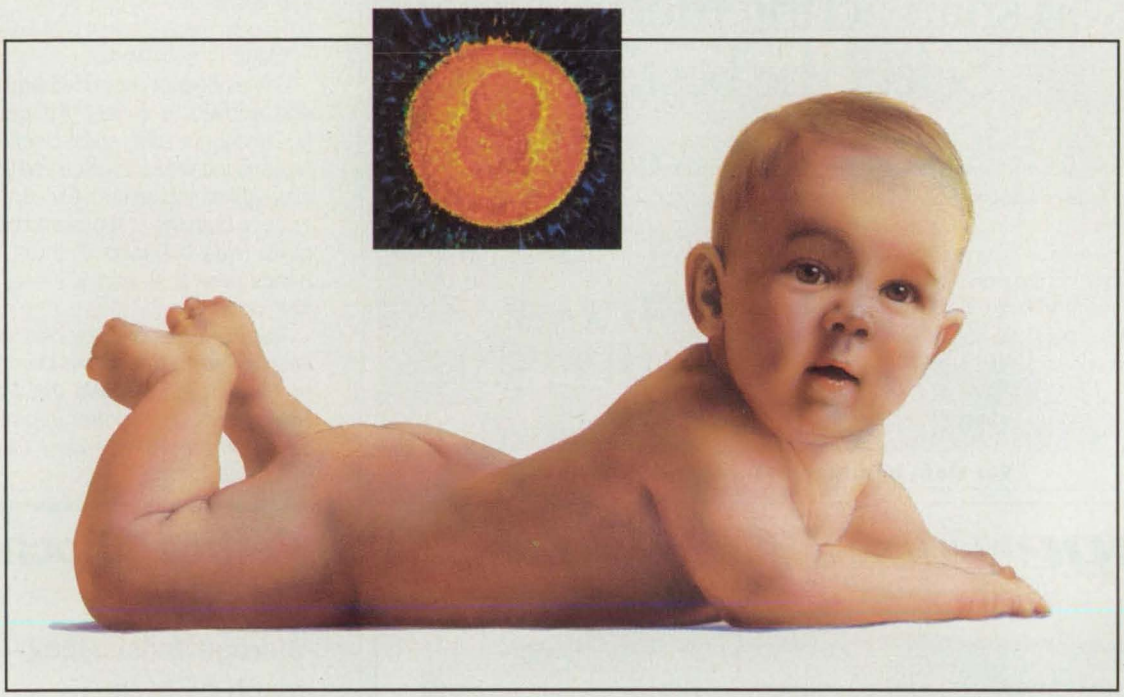

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For More Information Circle No. 423

within acceptably narrow ranges. In some cases, the iteration may not converge in this way, and one might have to accept a larger R at the lowest frequency.

3. Compute more-accurate values of R and D at the intended operating frequencies by applying a physical-optics analysis to the beam waveguide that has the parameters found in step 2.
4. To offset the discrepancy between the Gaussian and physical-optics results, repeat step 1, iterating the unknown parameters until the differences between the Gaussian values of R at the design frequencies are approximately equal in magnitude but opposite in sign to those found in step 3. Perform a similar adjustment for the values of D.
5. Repeat steps 3 and 4 until an acceptable result is achieved.

The procedure described was developed and applied to a very-high-performance and wideband (dual-shaped reflector) 34-m antenna fed with a three-curved-mirror beam waveguide subsystem. Excellent performance of both the antenna and beam waveguide was obtained at three frequency bands near 2, 8, and 32 GHz, a span of four octaves.

This work was done by Watt Veruttipong, Jacqueline C. Chen, and Dan A. Bathker of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 11 on the TSP Request Card.*
NPO-18512

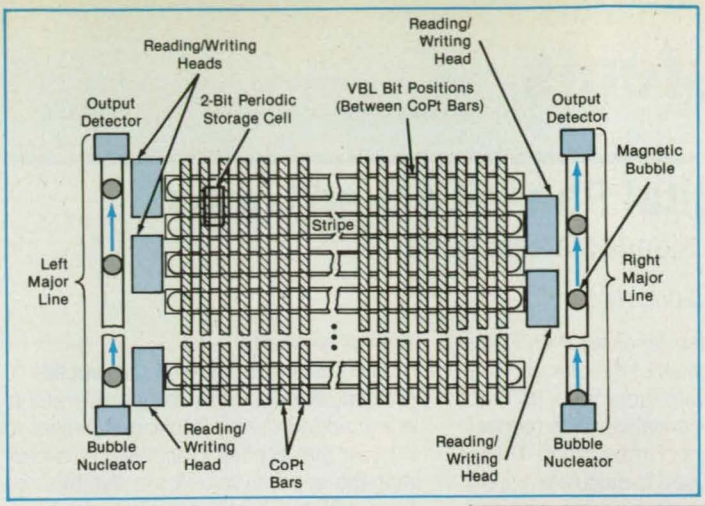
Vertical-Bloch-Line Memory

Storage density may reach 1 Gb/cm^2.

NASA's Jet Propulsion Laboratory, Pasadena, California

The vertical-Bloch-line memory is a developmental very-large-scale integrated-circuit block-access magnetic memory. It offers the advantages of resistance to ionizing radiation, potential areal storage density $\leq$ 1 Gb/cm^2, data rates $\leq$ 1 Gb/s, and average access times of the order of milliseconds. Furthermore, its mass, volume, and demand for power are expected to be less than those of other magnetic and electronic memories. Preliminary designs have been formulated, and the functionality of some parts has been verified.

The storage medium is a film of a magnetic garnet or other suitable ferromagnetic material. Blocks of data are stored in stripes, the locations of which are stabilized and demarcated by grooves in the medium. The magnetic anisotropy of the medium is such that the magnetization lies



The **Vertical-Bloch-Line** memory stores data in the form of localized pairs of twists (VBL pairs) in the magnetic field at the edge of the ferromagnetic domain in each stripe. The presence or absence of a VBL pair at a bit position denotes a one or a zero, respectively.

perpendicular to the plane of the film, the bulk of the film being magnetized in one direction and the stripe constituting a ferromagnetic domain magnetized in the opposite direction.

A vertical Bloch line (VBL) is a twist of magnetization in the Bloch wall (the boundary of the domain) in the plane of the film. Two such twists constitute a VBL pair. If both VBL's in a pair have the same chirality, then the pair is stable, and its size is much less than 1 μm. Data are stored by use of VBL pairs: the presence or absence of a VBL pair at a bit-cell location represents a binary 1 or 0, respectively.

The figure illustrates the main functional areas of the VBL memory. The VBL storage area confines and stabilizes the stripe domains. An array of CoPt bars (which are magnetically hard) imposes a periodic magnetic field and, thereby, a periodic potential well that stabilizes the position of each VBL pair along each stripe. During reading, a reading/writing head converts VBL pairs at the end of a stripe into magnetic bubbles; during writing, it converts magnetic bubbles into VBL pairs.

Each major line includes (1) a bubble nucleator (essentially, a conductor with a hairpin loop) that converts input electrical signals into magnetic bubbles, (2) an output detector that converts the magnetic bubbles into output voltages via the magnetoresistive effect, (3) a track along which bubbles propagate from the nucleator to the reading/writing gates (during writing) or from the reading/writing gates to the output detector (during reading), and (4) an expander, which stretches each bubble to a desired length to provide a satisfactory signal-to-noise ratio at the output.

This work was done by Romney R. Katti, Jiin-Chuan Wu, and Henry L. Stadler of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 1 on the TSP Request Card.*
NPO-18467

Suppressing Transients in Digital Phase-Locked Loops

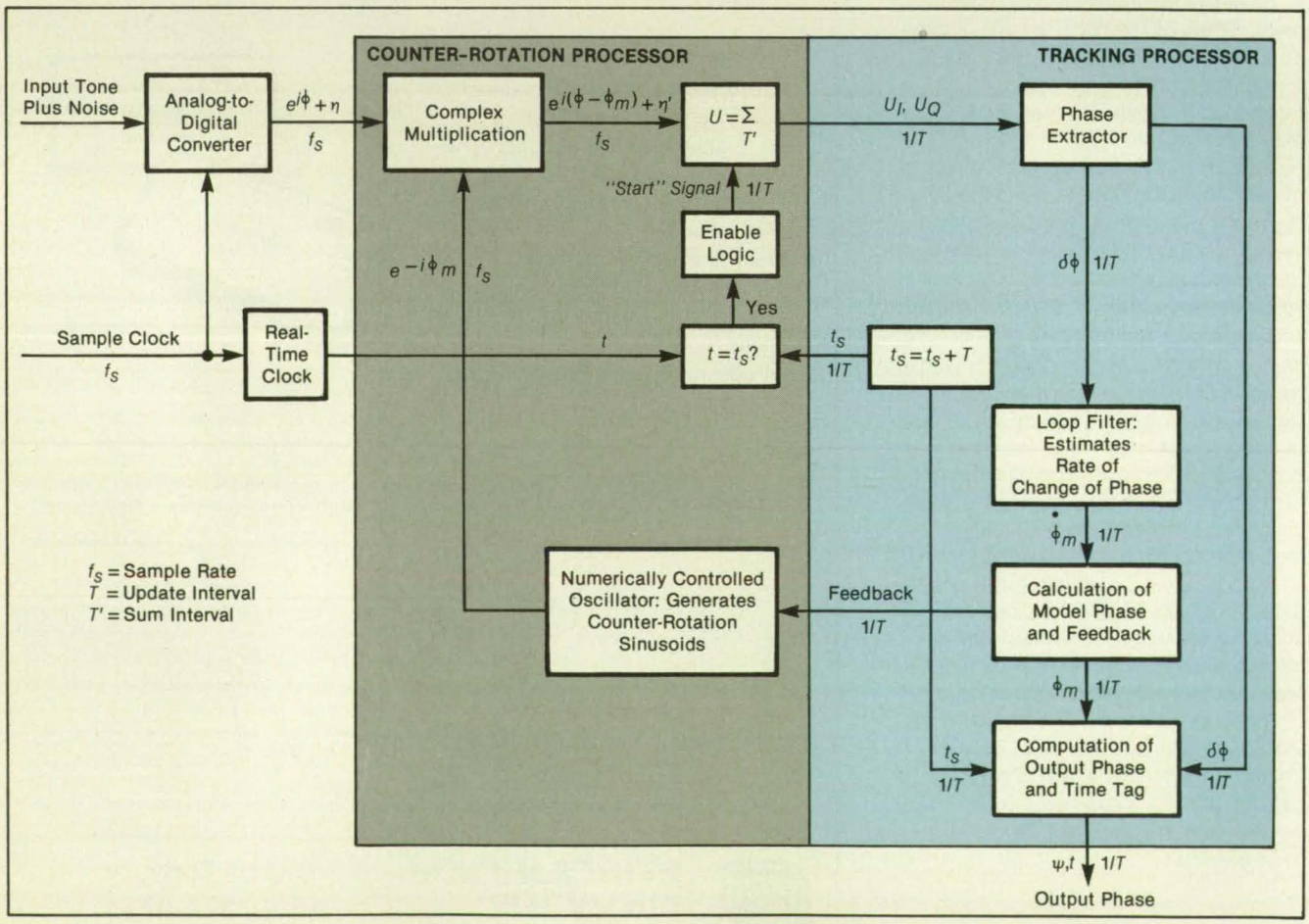
In principle, a loop of arbitrary order can start in steady-state lock.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method for initializing the variables of a digital phase-locked loop (see figure) reduces or eliminates the transients in phase and frequency that typically occur (1) during acquisition of lock on a signal or (2) when changes are made in the values of the loop-filter parameters called "loop constants" (which are ordinarily held constant but are sometimes changed suddenly to new values). Notably, the method enables direct acquisition by a third-order loop without prior acquisition by a second-order loop of greater bandwidth, and can eliminate even those perturbations in phase and frequency lock that would otherwise occur when loop constants are changed by arbitrarily large amounts.

Feedback to the numerically controlled oscillator in the loop consists of the estimated phase and the estimated rate of change of phase. The part of the method that applies to the acquisition of lock depends on the availability of sufficiently accurate initial estimates of the phase of the signal and, for a third-order loop, its first, second, and third derivatives with respect to time at the instant of initialization. These estimates can be used to calculate a priori values for the two loop sums and the steady-state phase error that would have been generated by the loop up to that instant if the loop had reached steady-state lock. When operation is started with the sums at these a priori values and the numerically controlled oscillator is started at the estimate of phase (projected to the next sampling instant) and at a frequency equal to the initial estimate of the rate of change of phase, then the loop as a whole starts in steady-state lock in phase and frequency. Indeed, software simulations have shown that if the signal-to-noise ratio is great enough and the initial estimates accurate enough, then the transients are negligibly small.

The part of the method that applies to resetting the loop when the loop constants are changed during tracking is similar to the part that applies to acquisition, except that the a priori values are synthesized from values computed by the loop during tracking up to the instant of change. For either acquisition or change in loop constants, the method can be adapted to orders higher and lower than third, by adjustment of the appropriate sums for each order. In a variation of the acquisition part of the method, one initializes the sums but not the estimated phase. For a third-order loop, for example, initialization of both sums can improve acquisition even if phase is not initialized. If only the rate of change (first derivative with respect to time) of phase is initialized, the loop must "pull in" (acquire) both the phase and the second derivative of phase with respect to time.



This **High-Level Block Diagram** illustrates the overall functions performed in a digital phase-locked loop.

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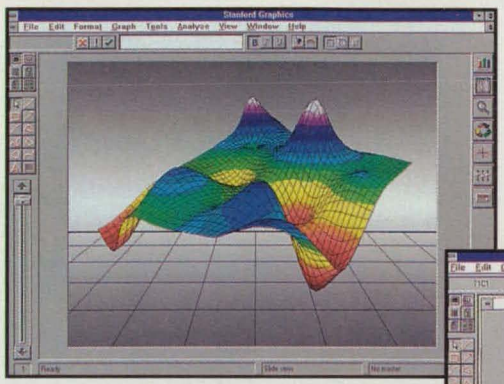

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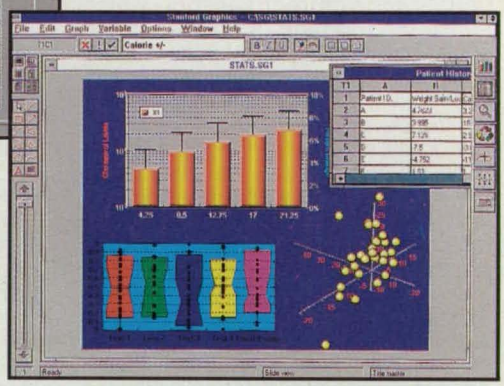

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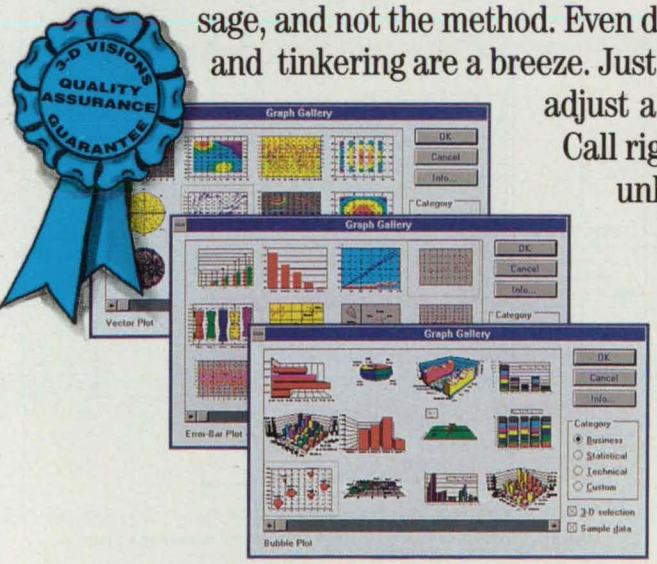

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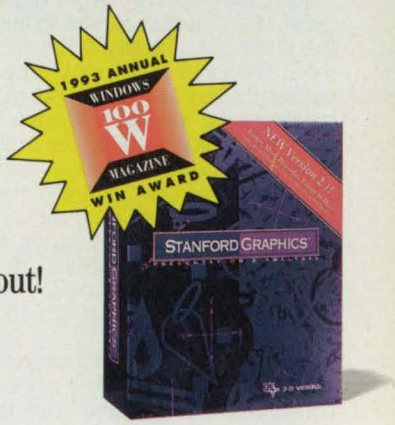

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If both the first and second derivatives are initialized, then the loop has to pull in phase only. Of course, for best acquisition, especially at a low signal-to-noise ratio, one should initialize the phase also.

This work was done by J. B. Thomas of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 92 on the TSP Request Card.*

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Refer to NPO-18539, volume and number of this NASA Tech Briefs *issue, and the page number.*

Shaft-Motion-Analyzing System

Signals from two optical sensors provide real-time indications of axial, radial, and rotational motions.

Lewis Research Center, Cleveland, Ohio

An optoelectronic system to monitor the motions of a turbopump shaft is being developed. It is necessary to monitor the incidental axial and the radial (orbital) displacement of the shaft as well as its desired rotation to obtain indications of progressive deterioration or impending failure. At least one monitoring system now in use depends on the use of eddy-current sensors, which sense the passage of notches in the shaft. The developmental system relies on optical sensors, so that it is no longer necessary to carve notches in the shaft.

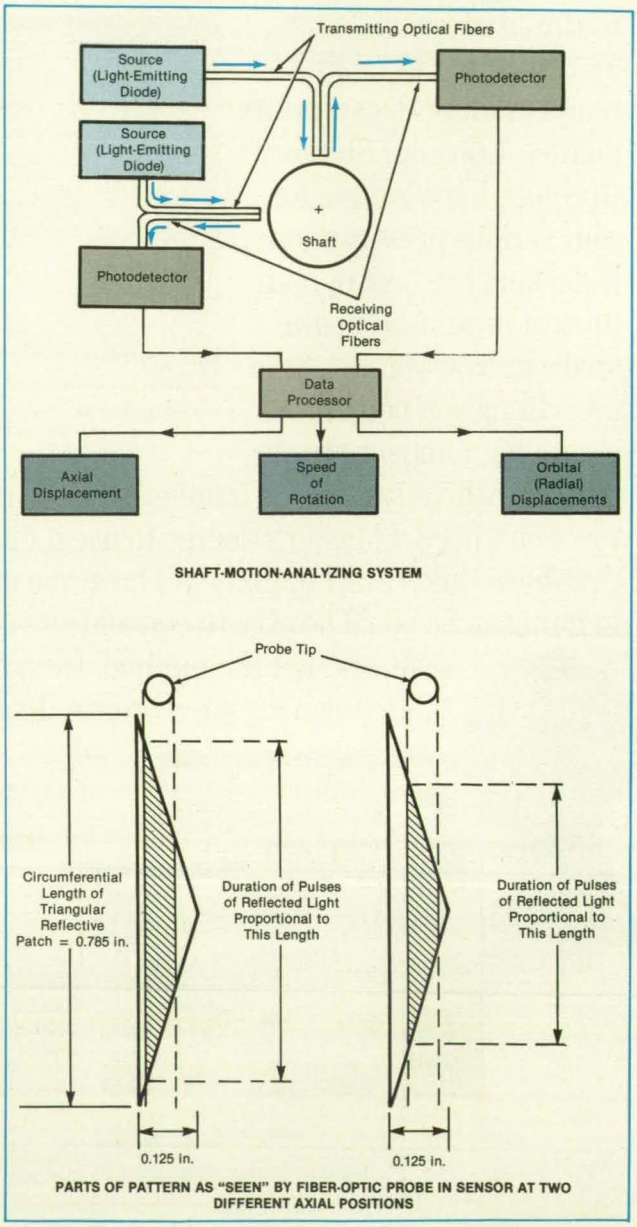
The developmental system includes two optical sensors: one facing the shaft vertically from the top, the other facing the shaft horizontally from the side (see figure). These sensors are positioned to detect changes in the light reflected from a pattern of light and dark (or reflective and non-reflective) triangles on the shaft. The axial position of each sensor relative to the midaxial height of the triangles is indicated by the ratio between the periods of light and dark detected during the rotation of the shaft. The speed of rotation of the shaft is measured as the rate of passage of the pattern. The relative radial position of the shaft at each sensor location can be determined from measurement of the changes in the intensity of light reflected from the pattern. These measurements and computations are performed in real time to provide simultaneous indications of the speed of rotation and the axial and orbital motions of the shaft.

The pattern includes eight identical isosceles triangles placed with their bases end to end along a circumference of the shaft. The diameter of the shaft is 1 in. (2.54 cm). The height of the triangles in the direction parallel to the axis of the shaft is nominally 0.125 in. (3.175 mm). The initial focal point of each optical sensor lies at the nominal axial midheight of the triangles. A signal-conditioning unit proposed for use in this system would compute the deviation from this axial midheight from the ratio between bright and dark periods mentioned previously. The range of axial measurement is nominally ± 30 mils (± 0.76 mm). the resolution is nominally 0.30 mil (0.008 mm) at speeds up to 200,000 rpm.

Each sensor is directly coupled to the input amplifier in another signal-conditioning unit. The gain and input offset are set by the operator for maximum sensitivity with no indication of gain or offset errors. When the amplifier is adjusted properly, its output fluctuates approximately symmetrically about 2.5 volts, and a dc reference in the signal-conditioning unit is automatically set, relative to the intensity of reflected light, when a sensor encounters the bright or reflecting portion of the rectangular pattern.

Measurements of radial position are updated 16 times per revolution. The analog signal from each optical sensor is converted to digital form by a flash encoder that has a range of 0 to 5 volts. If the signal goes negative or exceeds the range of the flash encoder, light-emitting-diode indicators on the front panel warn the operator of offset or gain error. One digital peak detector searches for the maximum signal level. An arithmetic unit computes a value midway between the minimum and maximum and puts out this value in analog form as a reference for a comparator that detects the transitions between the bright and dark regions of the pattern.

The output of the comparator for each signal channel and the digital values from the flash encoder for each signal channel are processed with pipeline parallel arithmetic circuits to obtain the required measurements of speed, axial position, and the two radial coordinates. The arithmetic results are converted to analog form for use by the operator.



Optical Sensors detect the passage of reflective triangles on the shaft. The optical measurements are processed in real time into indications of the speed of rotation and of the axial and lateral displacements of the shaft.

This work was done by Richard L. Randall, John J. Collins, Paul T. Coleman, and Edmund J. Roschak of Rockwell International Corp. for **Lewis Research Center.** *No further documentation is available. LEW-15065*

Low-Jitter Digital Rate Multiplier

Two minor clock periods differ by one master-oscillator period.

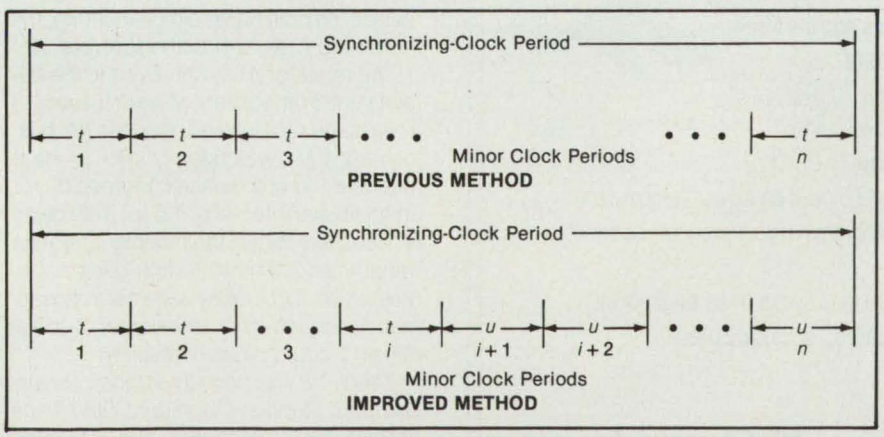
Goddard Space Flight Center, Greenbelt, Maryland

The jitter in a digital rate multiplier can be reduced by an improved method that involves the use of two slightly different minor clock periods (which are defined below). In the original application for which the method was conceived, the problem is to divide the measured period of spin of a spacecraft (e.g., 5 seconds) into a large number (e.g., 16,384) of equal subintervals, by counting cycles of a master oscillator that runs at a high frequency (e.g., 10 MHz). The method can also be used to reduce jitter in other situations in which it is necessary to generate equal subintervals from a synchronizing clock signal of arbitrary period (or equivalently, to multiply the clock rate by a specified integer). The method is particularly valuable in situations in which synchronizing signals can be lost temporarily and where drift in an analog circuit would be unacceptable (e.g., at least 30 minutes).

Heretofore, the standard practice in digital rate multiplication has been to generate equal (though slightly erroneous) minor clock periods by repeatedly counting out the same number, t, of master-oscillator cycles. Of course, this number can be adjusted upon receipt of the next synchronizing clock pulse, but until then, each minor clock period can be in error by as much as half a master-oscillator period. The total error that can be accumulated during one period of the synchronizing clock is thus $nT_{osc}/2$, where n is the chosen number of minor clock periods and T_{osc} is the period of the master oscillator.

In the improved method, the set of n minor clock periods is divided into two subsets. Each of minor clock periods 1 through i contains t master-oscillator cycles. Each of minor clock periods $i+1$ through n contains u master-oscillator cycles, where u and t differ by exactly 1 (see figure). By appropriate choice of t (or, equivalently, of u) and i, the maximum error accumulated during a synchronizing-clock period can be reduced to $T_{osc}/2$. Thus, in the improved method, the accuracy of the synthesized version of the synchronizing-clock period is limited only by the frequency stability of the master oscillator.

This work was done by Richard B. Katz and Glenn P. Rakow of **Goddard Space Flight Center**. *For further information, Circle 43 on the TSP Request Card.*
GSC-13545



Minor Clock Periods are made slightly unequal in the improved method. This makes it possible to reduce the total error accumulated during the synchronizing-clock period by canceling errors of minor clock periods that are slightly too long with opposing errors of minor clock periods that are slightly too short.

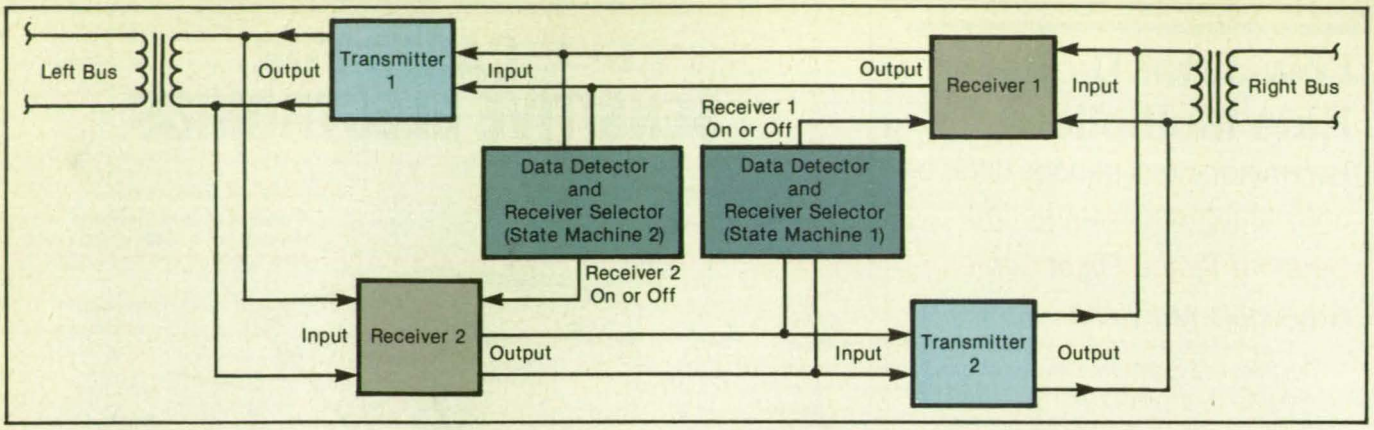
Repeater for a Digital-Communication Bus

Crosstalk and instability are eliminated.

Lewis Research Center, Cleveland, Ohio

A digital repeater circuit is designed to extend the range of communication on a MIL-STD-1553 bus beyond the original maximum allowable length of 300 ft (about 90 m). The circuit provides two-way communication, one way at a time, and otherwise conforms to the specifications of MIL-STD-1553.

The major component of the repeater is a commercial UTM63M125 bus transceiver, which consists of two transmitter/receiver pairs that conform to MIL-STD-1553A and MIL-STD-1553B. The operation of the transmitters and receivers is coor-



The **Bus Repeater** extends the range of communication on a MIL-STD-1553 bus, providing transmission in either direction. The delay through the repeater during transmission in one direction is 380 ns. To prevent instability, the repeater imposes a "time out" of 1.5 μs after completion of a message before allowing transmission in the reverse direction.

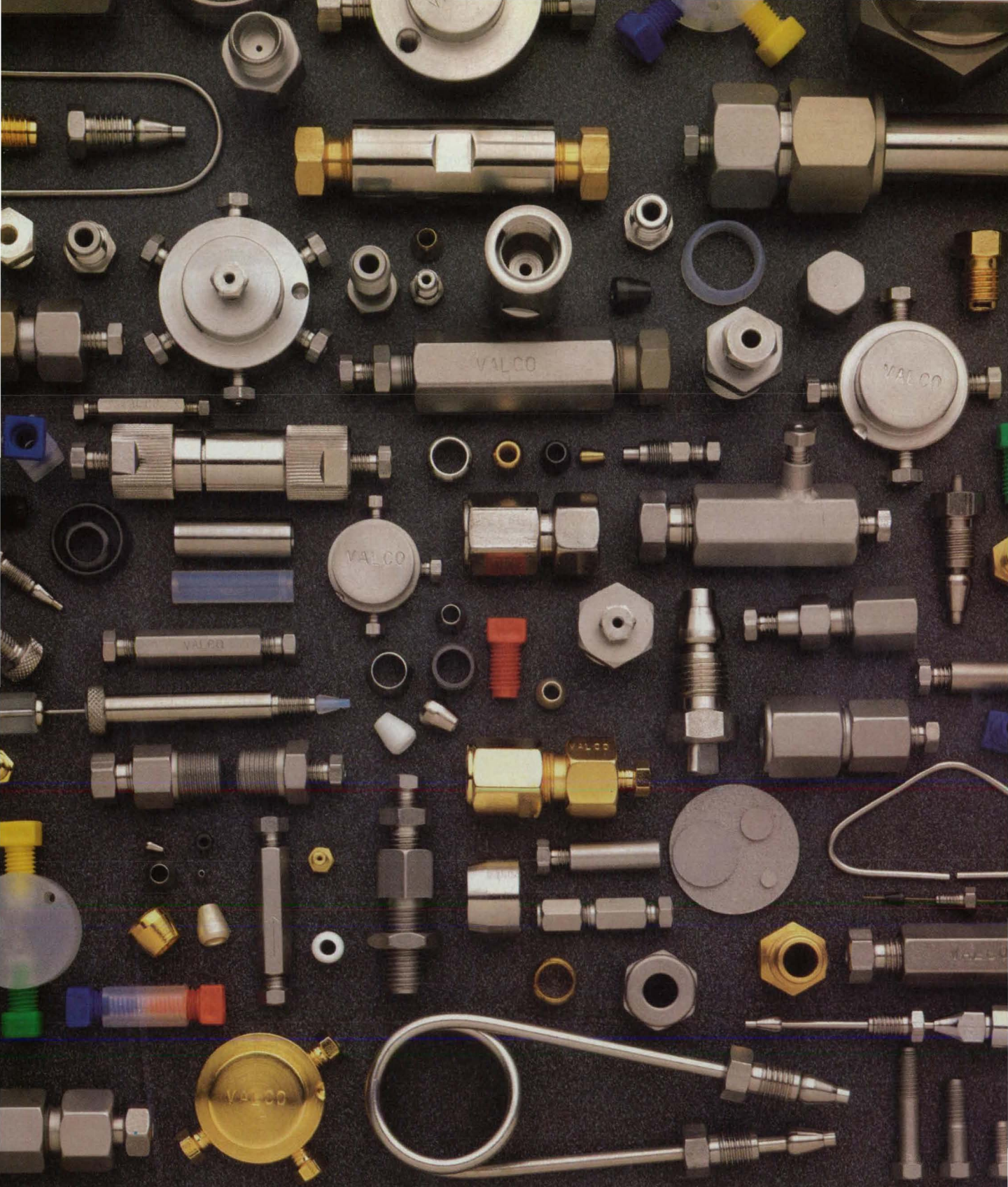
dinated by two data-detector/receiver-selector circuits, also called "state machines," that are designed specifically for the purpose (see figure). Each state machine contains the functional equivalent of a NOR gate and a "watchdog" timer. When the output of each state machine is high or low, the receiver that it controls is turned on or off, respectively.

When no signal is coming in on either bus, the repeater eventually goes into a "default" state, in which both receivers are turned on. In this state, the outputs of both receivers on both lines are low, and the output of each state machine is high. Consequently, both receivers remain on and nothing else happens.

When a signal comes in on, say, the left bus, the voltage on one of the output lines of receiver 2 goes high, causing the output of state machine 1 to go low. This action turns off receiver 1, so that signals can pass through the repeater in only one direction: from the left bus through receiver 2 and transmitter 2 to the right bus. The repeater operates similarly when a signal comes in on the right bus, except that the roles of the transmitters, receivers, and state machines are interchanged to effect transmission from right to left. In case of an erroneous condition in which signals come in on both buses simultaneously, the state machines turn both receivers off.

The repeater does not revert to the default state immediately when at the end of a message received on, say, the left bus. Instead, the "watchdog" timer in state machine 1 keeps receiver 1 turned off for an additional interval of 1.5 μs. This delay is necessary to give the recently operating transmitter 2 time to switch back to the quiet state. If this delay were not imposed, then feedback from transmitter 2 to receiver 1 could cause instability.

This work was done by Esteban Torres-Guzmán, Stephen Olson, and Tim Heaps of Rockwell International Corp. for **Lewis Research Center**. *For further information, Circle 72 on the TSP Request Card.*
LEW-15177



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Physical Sciences

Three-Rod Linear Ion Traps

Ions could be trapped outside the electrode structures.

NASA's Jet Propulsion Laboratory, Pasadena, California

Three-parallel-rod electrode structures have been proposed for use in linear ion traps and possibly for electrostatic levitation of macroscopic particles. Linear ion traps are important components of atomic frequency standards. The trapping potential field in a linear ion trap is created by applying (1) a common dc electrostatic potential to cap electrodes placed near both ends of the rod electrodes and (2) radio-frequency alternating potentials to the rod electrodes.

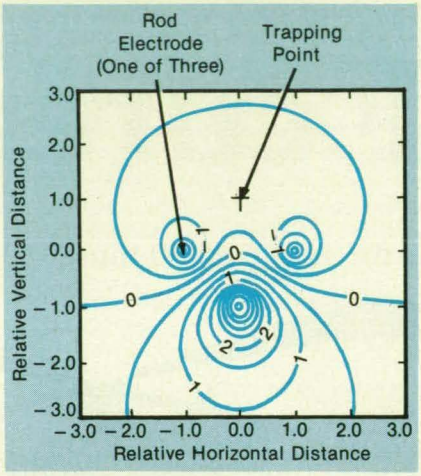
The trapping potential well is centered at a point near the midlength of the rods, and the electrostatic field and trapping potential in the well can be computed, to a close approximation, from the two-dimensional electrostatic field generated by rod electrodes that are infinitely long. The trapping potential Ψ, at a point in space is given by

$$\Psi = \frac{e^2E^2}{4m\Omega^2}$$

where e is the electric charge of an ion, m is the mass of an ion, E is the root-mean-square magnitude of the alternating electrostatic field at that point, and Ω is the frequency of alternation of the applied voltage.

A typical linear ion trap in current use is a four-rod, quadrupole-field device, which traps ions in a narrow region along the axis of symmetry that is surrounded by the rods. A two-rod device with both rods driven at the same voltage with respect to a distant boundary can also trap ions on the axis of symmetry between the rods. A two-rod trap allows access to the trapping region from a wider range of viewing directions than does a four-rod trap.

The proposed three-rod traps could provide an even wider viewing angle, because they could confine ions in regions outside the rod-electrode structures. To simplify the calculation of the trapping field, the electrostatic field generated by each rod electrode can be approximated as the electrostatic field generated by charges concentrated on the axis of the rod. The figure shows the electrostatic field and trapping point of a three-rod trap with zero net line charge, as calculated by use of this approximation.



The Electrostatic Field of a three-rod ion trap is shown here in cross section viewed along the rods. The numbers and contours indicate relative potentials in the alternating electrostatic field. The trapping point is the intersection of the trapping line with the cross-sectional plane.

This work was done by Gary R. Janik, John D. Prestage, and Lutfollah Maleki of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 4 on the TSP Request Card.*
NPO-18103

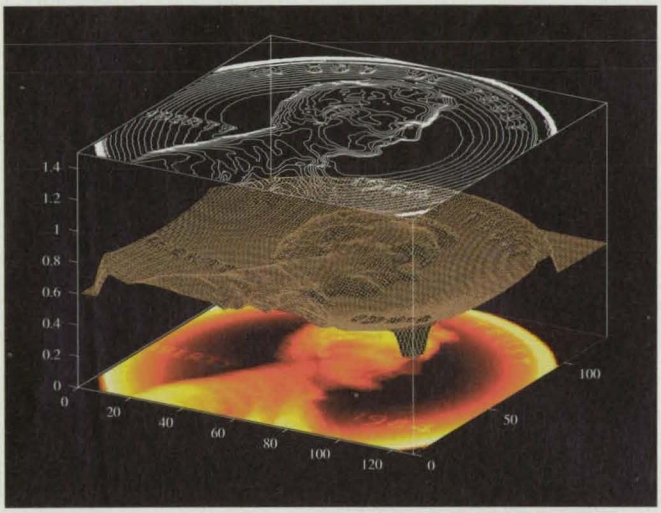
Piezoelectrically Bendable Mirrors for Spatial Modulation of Light

Potential applications include optical computing and astronomy.

NASA's Jet Propulsion Laboratory, Pasadena, California

Flexible mirrors that include multiple small piezoelectric actuators (bimorphs) attached to their back (nonreflecting) surfaces are being developed. Mirrors of this type could be used as spatial light modulators in optical computers, to compensate for atmospheric distortions in astronomical telescopes, and in other applications in which wave fronts are required to be altered controllably. In comparison with piezoelectrically and otherwise actuated mirrors developed previously for adaptive optics, the

We see your expectations of visualization and we raise them.



Three views of the surface height of a penny show user customizable object-oriented graphics in MATLAB 4.0. Data courtesy of NIST.

Combine advanced visualization with the powerful computation of MATLAB, and gain new insight into your most challenging problems.

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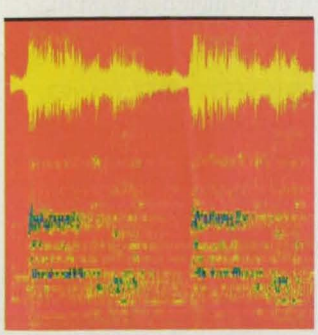

Spectrogram of Handel's Hallelujah Chorus, *computed and displayed with MATLAB 4.0 and the Signal Processing Toolbox.*

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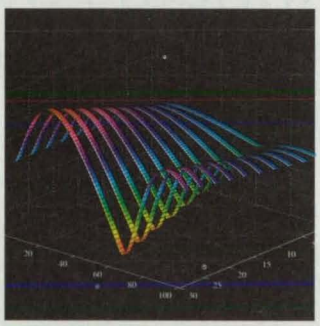

Frequency responses of a family of control systems, modeled, simulated and visualized in MATLAB 4.0.

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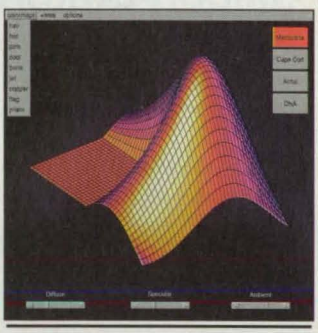

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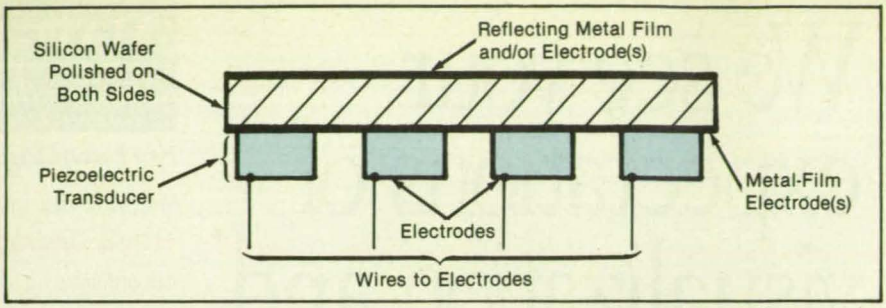
multiple-bimorph mirrors weigh less, respond faster, can be actuated by lower voltages, and can include larger numbers of bending actuators for finer control of surface contours.

A typical mirror of this type (see figure) is made from a thin single-crystal silicon wafer (or from a metal or another semiconductor) that has been polished to optical quality on both sides. If the mirror is made of a semiconductor, then the back side is covered with either a continuous metal film or a pattern of many metal-film electrodes. The front surface is covered optionally with a similar electrode pattern, covered with a continuous reflective metal film, or left untreated, depending on the specific design.

A large number of small, thin piezoelectric actuators are attached (e.g., by glueing or soldering) to the metalized back surface, forming a multiple piezoelectric bimorph. The piezoelectric actuators can include electrodes on the attachment side. One electrode or several subelectrodes can be included on the free side of each actuator. Voltages are applied to the various electrodes, causing the multiple piezoelectric bimorphs to apply corresponding local bending distortions to the mirror. These distortions can be controlled to alter the reflected wave front(s) according to the desired spatial-modulation scheme.



Multiple Piezoelectric Actuators attached to the back of the mirror apply controlled local bends. Thus, the reflecting surface can be altered to modulate the reflected light.

In a proposed, more advanced version, bending voltages would not be applied directly. Instead, bending would be controlled by illuminating (1) the silicon wafer (if one is used) with a pattern of visible or near-infrared light or (2) the piezoelectric actuators with visible or infrared light. In either case, the illumination would cause the local accumulation of electric charges, which would influence the local bending.

This work was done by Erez N. Ribak of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 79 on the TSP Request Card.*
NPO-18639

Silicon-Etalon Fiber-Optic Temperature Sensor

The output is highly immune to extraneous effects.

Lewis Research Center, Cleveland, Ohio

A developmental temperature sensor consists of a silicon Fabry–Perot etalon attached to the end of an optical fiber. Like other fiber-optic temperature sensors, this one features immunity to electrical interference, small size, light weight, safety, and

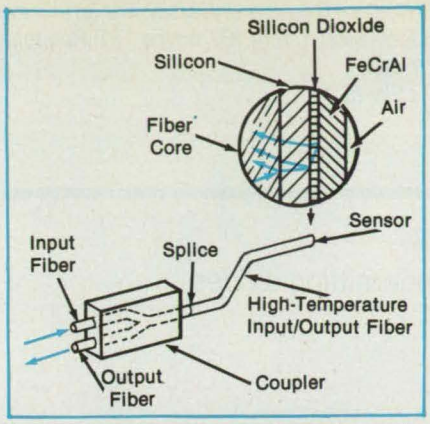


Figure 1. The **Temperature Sensor** is made by sputtering Si, SiO_2, and FeCrAl films directly onto the end of the optical fiber.

chemical inertness. In addition, its output is encoded in the ratio of intensities at two different wavelengths, rather than in overall intensity, with the result that the temperature readings are not degraded much by changes in the transmittance of the fiber-optic link (e.g., transmissivity changes due to remating of connectors or bending of fibers).

The reflectance of a Fabry–Perot etalon is a minimum at each of its resonant wavelengths, λ_m, which are given by $\lambda_m = 2nd/m$, where n is its index of refraction, d is the thickness, and m is an integer. If the etalon reflectance is measured at wavelengths on either side of a resonance, then, if the resonant wavelength changes, due for instance to a change in refractive index, then one of the monitored light intensities will increase while the other will decrease. The ratio of these two intensities will then vary as a monotonic function of the refractive index. Because the refractive index of silicon depends strongly on temperature, this two-wavelength scheme can be used together with a silicon etalon to measure temperature.

For the sake of small size, ruggedness, and ease of manufacturing, the silicon film that is to become the temperature-sensing etalon is sputtered directly onto the end of a multimode optical fiber, to a thickness of 1.4 μm (see Figure 1).

Next, without breaking vacuum, a two-layer reflective and protective structure is deposited: SiO_2 of thickness 0.14 μm, and an FeCrAl alloy (77.5:10.6:11.9 by weight) with a thickness of about 1 μm. The opaque FeCrAl film blocks out stray light and prevents dirt and other contaminants from interfering with the guided light. Since this alloy, like stainless steel, forms a protective scale when exposed to an oxidizing environment, it is also expected to protect the underlying silicon from oxidation. The SiO_2 serves to prevent the diffusion of the constituents of the metal film into the silicon film, which would irreversibly alter its refractive index. The SiO_2 thickness is chosen to maximize the intensity of the light reflected back through the silicon film.

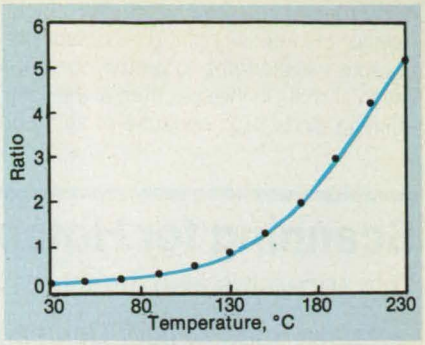


Figure 2. The **Ratio Between the Signals** in two spectrometer channels in an experimental version of the fiber-optic temperature sensor is a function of the temperature.

The sensed temperature is determined by illuminating the etalon with broadband light from a light-emitting diode (LED), and then measuring the intensity of the reflected light at two appropriate wavelengths using a miniature optical spectrometer. Figure 2 shows how the ratio of these signals varies as a function of temperature.

A more-sophisticated approach might monitor the intensity of the reflected light at more wavelengths to permit compensation of shifts in the spectrum of the light-emitting diode (e.g., because of aging or changes in ambient temperature).

This work was done by Glenn Beheim of **Lewis Research Center**, *Klaus Fritsch of John Carroll University, and Joseph M. Flatico and Massood Tabib Azar of Case Western Reserve University. For further information, Circle 101 on the TSP Request Card.*

LEW-15117

Scanning for Hotspots in Lamp Filaments

This apparatus also measures diffraction patterns and outputs of light-emitting diodes.

Goddard Space Flight Center, Greenbelt, Maryland

A scanning photometer has been designed for use in an investigation of failures of incandescent lamp filaments. The basic idea is to map the brightness as a function of position along each filament to identify bright (hot) spots, which occur at notches and thus signify incipient breaks or rewelds. The scanning photometer has also been used to measure the nonuniformity in the outputs of such linear (in the spatial sense) devices as light-emitting diodes, and to measure diffraction patterns of lenses.

The scanning photometer (see Figure 1) includes a lens that projects an image of the filament onto a solar cell. A mask with a narrow slit perpendicular to the axis of the filament allows only a short slice of the filament image to illuminate the solar cell. The solar-cell assembly is connected to a precise threaded shaft, which is rotated slowly by a constant-speed motor to scan the solar cell along the image of the filament. The output of the solar cell is measured at prescribed intervals along the scan, yielding data on brightness as a function of position along the filament.

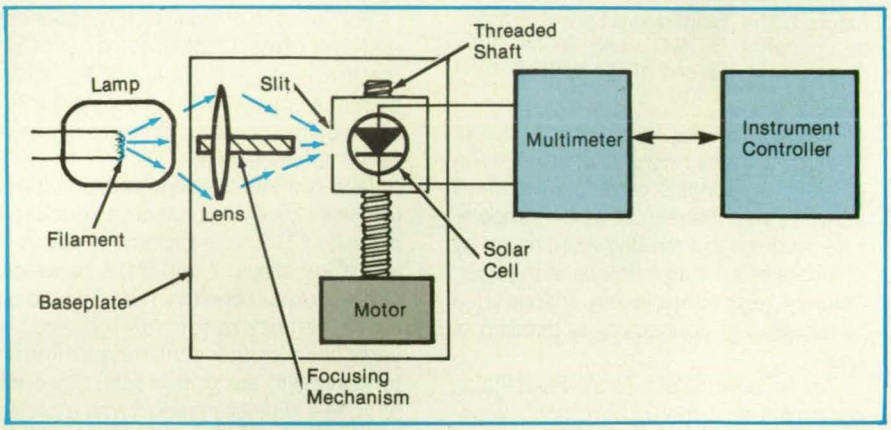


Figure 1. This **Scanning Photometer** measures the local brightness of the filament as a function of position along the filament.

Figure 2 shows three scans of a filament, taken at 2-day intervals. The first and second scans show the development of a hotspot that eventually results in a reweld. The third scan, taken after the reweld, shows a darker, less peaked distribution of light, indicating that the hotspot has disappeared.

This work was done by Charles E. Powers, Tim Van Sant, and Henning Leidecker of **Goddard Space Flight Center**. *Further information may be found in NASA RP-1273 [N92-20063], "Long-Term Life Testing of Geostationary Operational Environmental Satellite (GOES) Encoder Lamps."*

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GSC-13531

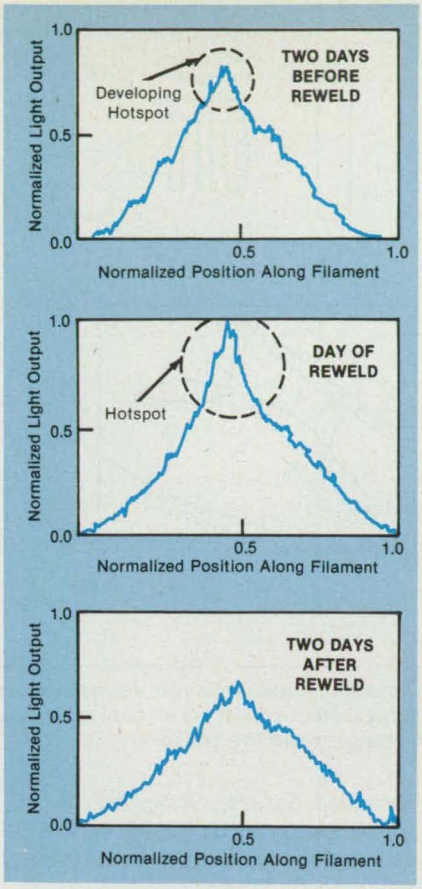


Figure 2. These **Scans Taken on Different Days** show a hotspot developing, then disappearing in a reweld.

Spectral-Content Readout of Birefringent Sensor

Stresses and strains can be measured optically at temperatures up to 2,000 °F (≈ 1,100 °C).

Ames Research Center, Moffett Field, California

Optical stress-and-strain sensors that function at ambient and high temperatures are being developed along with the associated readout equipment and data-processing techniques. These sensing systems are based on the well-known relationships between stress (or, equivalently, strain) and birefringence.

The figure is a schematic diagram of a conceptual system in which the sensor would be a photoelastic material — a material in which birefringence is induced by applied stresses. An optical fiber would carry white light from a lamp or other source to a polarizer. The polarized light would pass through the birefringent sensor and an analyzer. The polarizer, analyzer, and sensor would be configured as a circular polariscope. The output of the analyzer, bearing the effects of the stress-induced birefringence, would be sent through a second optical fiber to a spectrometer. In the spectrometer, a diffraction grating would disperse the light into a number of beams, each containing a different narrow band of wavelengths. The beams would be focused onto an array of photodiodes, the outputs of which would be recorded.

The spectral intensities, as embodied in the outputs of the photodiodes, would then be processed to extract the information on stress-induced birefringence and the causative stresses and strains. The principle of spectral-content readout is based on the equation

$$T_M(\delta, \lambda_j) = \frac{i(\lambda_j)}{S(\lambda_j)}$$

where λ_j = the middle wavelength of the wavelength band of the jth photodetector, and $S(\lambda_j)$ is the spectral-response factor of the overall system, established by calibration. $T_M(\delta, \lambda_j)$ represents the spectral-transmittance factor attributable to bire-

fringence; namely,

$$T_M(\delta, \lambda_j) = \begin{cases} \sin^2\left(\frac{\pi\delta}{\lambda_j}\right) & \text{in the dark-field optical configuration} \\ \cos^2\left(\frac{\pi\delta}{\lambda_j}\right) & \text{in the bright-field optical configuration} \end{cases}$$

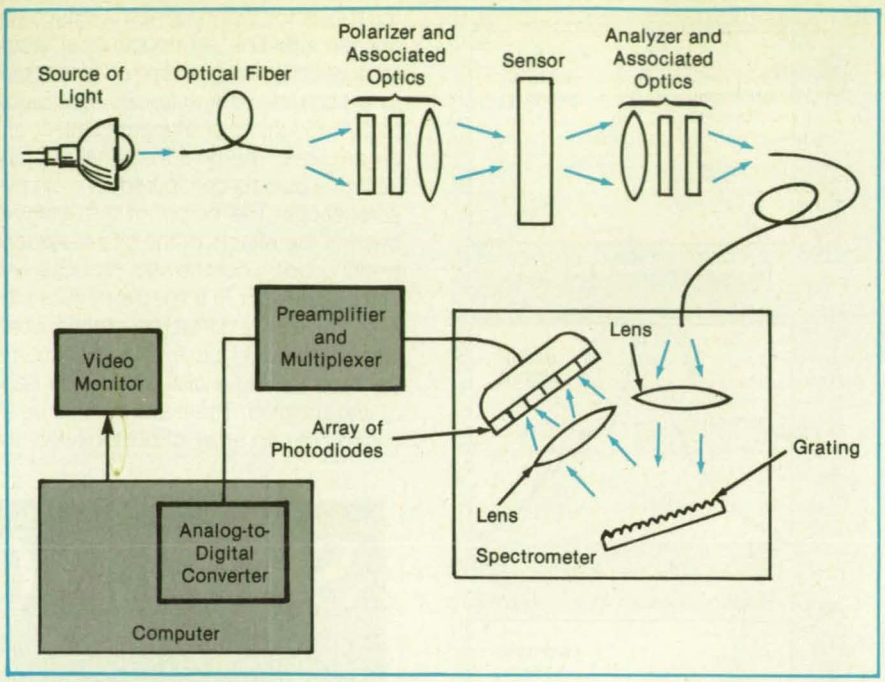
where δ is the length of retardation introduced by the birefringence.

The quantity to be determined is δ, inasmuch as it embodies the information on birefringence. The measurement data $i(\lambda_j)$ and the calibration data $S(\lambda_j)$ are first used to compute the actual $T_M(\delta, \lambda_j)$; then a computer search is performed to find the value of δ for which the applicable $\sin^2(\frac{\pi\delta}{\lambda_j})$ or $\cos^2(\frac{\pi\delta}{\lambda_j})$ best fits the actual $T_M(\delta, \lambda_j)$.

This method of measuring stresses and strains offers the same advantages as those of electrical strain sensors, including acquisition of data from multiple locations and under dynamic conditions. It offers the additional advantage of the immunity of fiber-optic transmission to interference by electromagnetic interference at radio and lower frequencies. The feasibility of operation at high temperatures was demonstrated in a prototype system in which a sensor made of fused silica was calibrated and tested at temperatures up to 2,000 °F (≈ 1,100 °C).

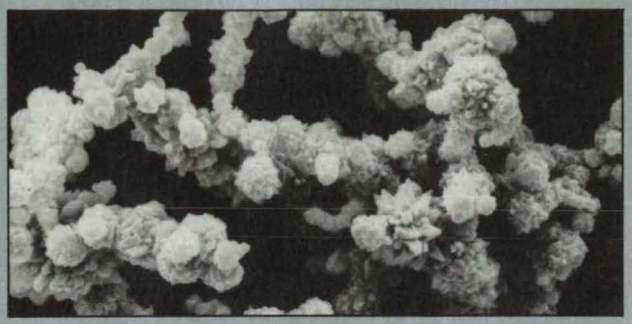
This work was done by Alex S. Redner of Strainoptic Technologies, Inc., for **Ames Research Center**. *Further information may be found in NASA CR-179444 [N90-14905], "Spectral Contents Readout of Birefringent Sensor."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-12969

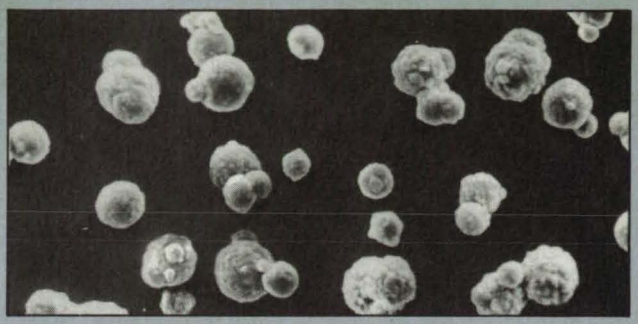


The Spectrum of Light processed through the polarizer, sensor, analyzer, and associated optical components would be measured and processed to extract the amount of retardation and, equivalently, the stress-induced birefringence in the sensor.

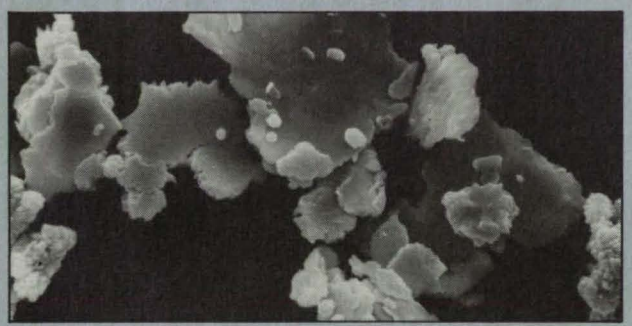
SPECIFY INCO SPECIALTY POWDERS FOR WIDE RANGE OF ELECTRONIC APPLICATIONS



Inco Type T 287 Filamentary Powder, particle size (FSSS) 2.6-3.3 microns, apparent density 0.75-0.95 g/cc, relative surface resistivity 0.30 ohms per square (□).



Novamet Silver Coated Nickel Spheres, 15% Ag, 2.5 g/cc apparent density, particle size 10 microns, screen mesh 99%-250, surface resistivity 0.03 Ω/□.



Novamet HCA-1 Flake, screen mesh 98% minus 400, apparent density 0.90 g/cc, thickness 1.0-1.1 microns, surface resistivity 0.25 Ω/□.

Novamet Nickel Coated Graphite, 60% fully encapsulated Ni, apparent density 1.6 g/cc, particle size (FSSS) 100 microns, screen mesh 63% −150/+250, surface resistivity 0.3 Ω/□.

Inco Specialty Powder Products now has a wide range of nickel and coated powders with exceptional conductive and magnetic properties. These properties make them ideal for a spectrum of electronic applications such as conducting film technology, coatings, adhesives, gaskets and EMI shielding.

EXTENSIVE PRODUCT RANGE

The development of computer processed control coupled with the continuous powder production improvements enables us to meet your most stringent powder specifications for electronic applications.

In addition to the products pictured above, INCO SPP has available the following high performance powder products. Novamet Conductive Nickel Spheres, particle size (FSSS) 8-9 microns, apparent density 3.2-3.5 g/cc, surface resistivity 1.0 ohms per square. Novamet 525 Conductive Nickel Pigment, screen mesh 100% minus 400, particle size 3.2 microns, 0.65 BET surface area m^2/g, surface resistivity 0.35 ohms per square. Silver Coated Nickel Flake, 15% Ag, 2.6 g/cc apparent density, particle size (FSSS) 15 microns, screen mesh 99% minus 200, surface resistivity 0.04 ohms per square.

Magnetic ferrites and surge arrestor applications also use our specialized range of nickel oxides. High Purity Black Nickel Oxide, 77.2% Ni, BET 75 (m^2/g) particle size (FSSS) 5.2 microns, minus 325 mesh 99% plus. Green Nickel Oxide, 78.5% Ni, BET 3 (m^2/g) particle size 1.6 microns, −325 mesh 100%.

Inco Specialty Powder Products is your unique source for custom fitting high performance powders into electronic applications. Our customer focused, world-wide marketing service group is ready to help you with your current and future needs.

For more information write INCO Specialty Powder Products, Dept. 1-90, Park 80 West-Plaza Two, Saddle Brook, NJ 07662

INCO SPP

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Shin-Muromachi Building, 4-3 Nihonbashi-Muromachi 2-Chome, Chuo-ku, Tokyo 103 Japan
1-3 Grosvenor Place, London SW1X7EA England
15/Fl Wilson House, 19-27 Wyndham Street Central, Hong Kong

For More Information Circle No. 535

Chemical Dosimeter Tube With Coaxial Sensing Rod

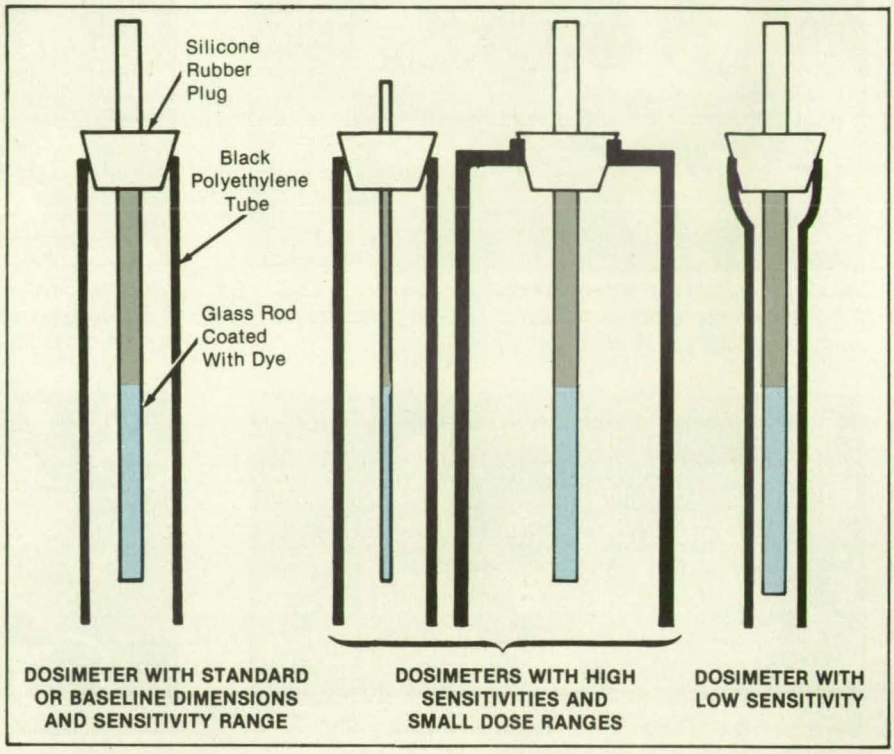
The length of rod along which color has changed indicates the total dose.

John F. Kennedy Space Center, Florida

An improved length-of-stain (LOS) chemical dosimeter indicates the total dose (integral of concentration over exposure time) of a chemical vapor in air. The dosimeter (see figure) includes an inner rod of glass or other smooth, nonporous, or hydrophobic material coated with a dye, the color of which changes in the presence of the chemical to be detected. This sensing rod is mounted coaxially in an outer tube, which serves as a diffusion barrier and shield against weather for the inner tube. The air to be monitored for the chemical vapor of interest is allowed to diffuse in from the open end of the tube. The length of rod along which the color changes increases with the total dose. Reproducible results in varying wind conditions are obtained by use of a diffusion barrier accross the open end of the outer tube.

The use of the rod as a smooth, continuous substrate to support the dye yields a fine-grained stain interface, which enables the dosimeter to indicate small changes in total dose. This contrasts with the coarse-grained stain interfaces of older LOS tubes, in which, typically, indicating dyes were coated on relatively-large-grained supporting granules. In comparison with older dosimeters, the improved coaxial-rod-and-tube dosimeter offers greater resistance to changing of the color of the exposed dye back to the color of the unexposed condition, greater sensitivity, and a higher degree of repeatability. Developed specifically to measure doses of gaseous HCl, the dosimeter can be modified by use of other dyes to indicate doses of other chemical vapors.

The dynamic range and sensitivity of the dosimeter can be field-adjusted by varying the ratio between the inner diameter of the tube and the diameter of the rod. When this ratio is larger, the dosimeter is more sensitive. For example, by choosing a suitably wide tube and narrow rod, one can make the dosimeter responsive to a dose as small as 2 ppm•min and to saturate at a relatively low maximum dose. Conversely, if the tube fits closely over the rod (if the ratio approaches its lower limit of 1), the diffusion volume becomes very small in comparison with the dye-covered area, and the dosimeter therefore becomes relatively insensitive and has a relatively large dose range.



Length-of-Stain Chemical Dosimeter Tubes can be made with rods and tubes of various diameters to obtain various sensitivities and dynamic ranges. The sensitivity is larger and the dose range smaller when there is more room for diffusion in the gap between the tube and the rod.

Alternative versions of the dosimeter could include tubes and/or rods of conical shapes that would yield more nearly linear color-change-length-vs.-dose calibration curves. Other modifications could include supports to help center rods in tubes, outer tubes made of opaque or ultraviolet-absorbing materials to reduce the effects of sunlight on the dyes, and/or calibration marks on the tubes to assist in reading doses. The use of nonporous materials to support dyes reduces fading of exposed dyes back to "unexposed" colors and could be extended to flat-badge dosimeters.

This work was done by Dale E. Lueck of **Kennedy Space Center**. *For further information, Circle 86 on the TSP Request Card.*
KSC-11574

Indium Foil Serves as Thermally Conductive Gasket

The foil deforms to fill imperfections on mating surfaces.

Lyndon B. Johnson Space Center, Houston, Texas

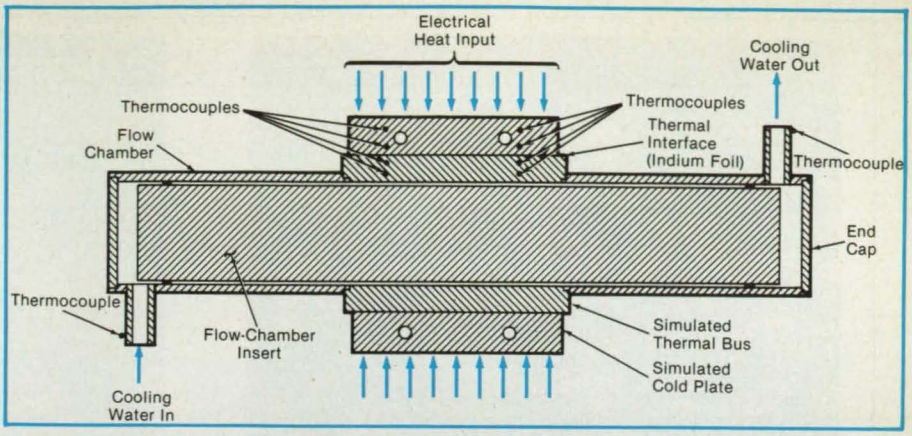
Indium foil has been found to be useful as a gasket to increase the thermal conductance between bodies clamped together. Imprecise mating of the surfaces of the bodies, with consequent low thermal conductance, can be caused by machining errors, thermal expansion, and mechanical stress. Furthermore, large joints are more vulnerable to these effects than

small joints are.

The indium foil is placed between the bodies, which are then clamped. The low tensile strength of the foil allows it to flow, when clamped, into the remaining gaps between the clamped bodies, assuring intimate thermal contact everywhere on the interface. When an indium foil 0.0019 in. (0.048 mm) thick was clamped in a cylindrical joint of area 239 cm^2 (see figure) at a pressure of 350 psi (2.4 MPa), the drop in temperature across it was less than 1 °C at a heat-flux density of 7 W/cm^2.

The indium-foil gasket can be used where the maximum temperature in the joint is less than the melting temperature of indium. Because of the low melting temperature of indium (156.6 1°C), it would probably be most useful in cryogenic applications.

This work was done by G. Yale Eastman and Peter M. Dussinger of Thermacore, Inc., for **Johnson Space Center**. *No further documentation is available.*
MSC-21493



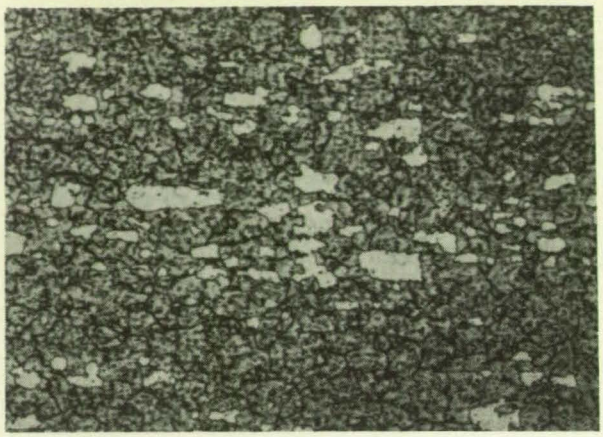
This **Test Apparatus** was used to verify the performance of indium foil as a thermally conductive gasket.

Powder-Metallurgical Bearings for Turbopumps

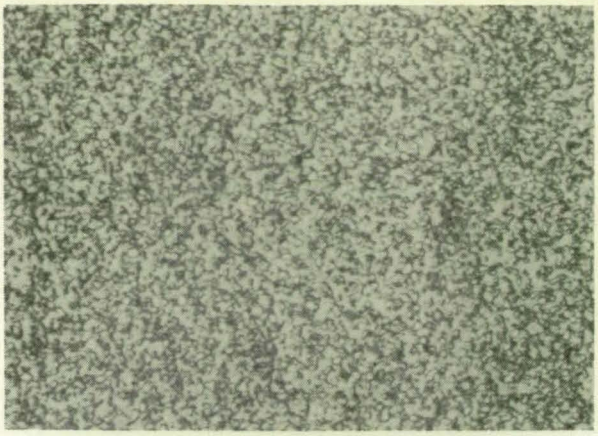
Improved bearing materials are needed to withstand extreme temperatures, cyclic stresses, and corrosion.

Marshall Space Flight Center, Alabama

Bearings fabricated by powder metallurgy are being developed for use in machines in which they would be subjected to extremes of temperature [from near absolute zero to over 1,000 °F (about 540 °C)], rolling-contact cyclic stresses, and oxidizing or otherwise corrosive fluids. In the original intended application, the powder-metallurgical bearings would serve as longer-lived replacements for the 440C stainless-steel bearings now used in the high-pressure oxygen turbopump of the



440C Stainless Steel



MRC-2001

Note: Magnification = 500

Powder-Metallurgical Alloy MRC-2001 has a finer microstructure than 440C stainless steel does. MRC-2001 has superior mechanical and chemical properties that are expected to yield longer service lives for highly stressed bearings in turbopumps and possibly other machines.

main engine of the Space Shuttle. Powder-metallurgical bearings may also extend the operating lives of other machines in which bearings are required to resist extreme thermal, mechanical, and chemical stresses.

The powder-metallurgical approach offers the opportunity to formulate new alloys that have the needed resistance to oxidation, wear, and rolling-contact fatigue. Furthermore, in powder metallurgy, one can form those alloys into components of nearly net size and shape, with consequent reduction of waste and cost. Typically, the microstructures of alloys made by advanced powder metallurgy are finer and more homogeneous than those of other alloys are (see figure). These microstructures feature small, uniformly distributed grains of primary carbides and uniform distributions of secondary phases and alloy elements. When a powder-metallurgy alloy is properly consolidated, the uniform grain structure is preserved in the alloy product, which is fully dense and suitable for use as a bearing material.

Some candidate alloys have been evaluated in comparison with each other and with 440C stainless steel via tests of rolling-contact fatigue, short-rod fracture toughness, cross-cylinder wear, and stress corrosion cracking. One alloy that exhibited outstanding properties was MRC-2001 (composition in weight percentages 75.2 Fe, 15.0 Cr, 6.0 Mo, 2.0 V, 0.5 Mn, 1.2 C, 0.1 Nb). The resistance of this alloy to fatigue, stress corrosion cracking, and wear was found to be superior to that of 440C stainless steel. This alloy has been selected for incorporation into bearings for full-scale tests.

This work was done by B. N. Bhat, T. S. Humphries, R. L. Thom, V. Moxson, G. I. Friedman, and F. J. Dolan of **Marshall Space Flight Center** *and R. J. Shipley of Materials & Manufacturing Technology Center. For further information, Circle 10 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24].Refer to MFS-28672.

Computer Programs

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COSMIC, NASA'S Computer Software Management and Information Center, distributes software developed with NASA funding to industry, other government agencies and academia.

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Computer Programs

These programs may be obtained at a very reasonable cost from COSMIC, a facility sponsored by NASA to make computer programs available to the public. For information on program price, size, and availability, circle the reference number on the TSP and COSMIC Request Card in this issue.

Electronic Components and Circuits

Program Diagnoses Nickel/Cadmium Batteries

NICBES2 assists in monitoring and managing the health of the batteries.

The Nickel Cadmium Battery Expert System-2 (NICBES2) computer program is a prototype expert-system program for the diagnosis and management of the health of nickel/cadmium batteries. NICBES2 is intended to support evaluation of the performance of batteries in the Hubble Space Telescope spacecraft and to alert personnel to possible malfunctions. To achieve this, NICBES2 provides a reasoning system supported by appropriate battery-domain knowledge.

NICBES2 oversees the status of the batteries by evaluating data gathered in orbit packets, and when the status so merits, raises an alarm and provides diagnosis of faults as well as advice on the actions to be taken to remedy the condition that gave rise to the alarm. In addition to diagnosis and advice, it provides a history of the statuses of the batteries pertaining to the health of the batteries. It also provides a graphical display to help the operator assimilate the information that it generates.

NICBES2 effects a composition of three cooperating processes driven by a program written in SunOS C. A serial-port process gathers incoming data from an RS-232 connection and places it into a raw-data pipe. Data-handler processes read this information from the raw-data pipe and perform statistical reduction of data to generate a set of reduced data files per orbit. An expert-system process starts the Quintus Prolog interpreter and the expert system and then uses the reduced data files for the generation of status and advice information.

The expert system presents the user with an interface window composed of six subwindows: Battery Status, Advice Selection, Support, Battery Selection, Graphics, and Actions. The Battery Status subwindow can provide a display of the current status of a battery. Similarly, advice on reconditioning, charging, and workload of a battery can be obtained

NASA Tech Briefs, June 1993

from the Advice Selection subwindow. A display of trends for the last orbit and over a sequence of the last 12 orbits is available in the Graph subwindow. A WHY button is available to give the user an explanation of the rules that the expert system used in determining the current information. The Support subwindow contains an editor for altering the knowledge base.

NICBES2 is written in C language and Quintus Prolog for Sun-series computers running SunOS. It requires 8 Mb of random-access memory for execution. The Quintus ProWindows graphics system is required for graphical display, and a PostScript printer is required to print graphics. A DEC LSI-11 is required to send telemetry via an RS-232 connection. The program is available on a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in UNIX tar format. NICBES2 was developed in 1989.

Sun and SunOS are trademarks of Sun Microsystems, Inc. PostScript is a registered trademark of Adobe Systems Inc. UNIX is a registered trademark of AT&T Bell Laboratories. DEC LSI-11 is a trademark of Digital Equipment Corp.

This program was written by Yvette B. Johnson and Alex Bykat of **Marshall Space Flight Center**. *For further information, Circle 60 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-28683.

Electronic Systems

Neural-Network-Development Program

NETS aids in the synthesis of back-propagation-learning neural networks.

NETS, a software tool for the development and evaluation of neural networks, provides a simulation of neural-network algorithms plus a computing environment for development of such algorithms. "Neural networks" denotes a class of systems modeled after the human brain. Artificial neural networks are formed from hundreds or thousands of simulated neurons, connected to each other in a manner similar to that of brain neurons. Problems that involve matching of patterns readily fit the class of problems that NETS is designed to solve.

NETS uses the back-propagation learning method for all of the networks that it creates. The nodes of a network are usually grouped together into clumps called layers. Generally, a network has an input layer through which the various environmental stimuli are presented to the network, and an output layer for determining the response of the network. The number of nodes in these two layers is usually tied to some features of the problem to be solved. Other layers, which form intermediate stops between the input and output layers, are called hidden layers. NETS enables the user to customize the patterns of connections between layers of a network. NETS also provides features for saving, during the learning process, the values of the weights (the strengths of the connections between neurons); these features provide for more-precise control over the learning process.

NETS is an interpreter. Its method of execution is the familiar "read–evaluate–print" loop found in such interpreted languages as BASIC and LISP. The user is presented with a prompt, which asks for input. After a command is issued, NETS attempts to evaluate the command, which may produce more prompts that request specific information or that signal an error if the command is not understood. The typical

NeuralWorks Professional II/PLUS

NeuralWorks Professional II/PLUS release 4.1 provides the user with some of the most powerful recent advances in neural technology. These include *Logicon Projection Network™**, Modular Neural Network, Fuzzy Art Map**, Radial Basis Functions, Quick-Prop, General Regression Neural Network* and updated versions of *Cascade Correlation and Probabilistic Neural Network.*

These enhancements provide the capability of solving difficult classification and modeling problems faster and more accurately than previously possible. Release 4.1 also includes a Train-Test option which optimizes neural network performance. This capability is enhanced by an optional proprietary network architecture optimization function exclusive to NeuralWare.

Ease of use and diagnostic capabilities have been enhanced with network specific instrument menus. A new diagnostic tool provides classification rate information. Specific menus have been develope for each of the major classes of neural networks with a special section for historical networks. Thi simplifies access to advanced network types with diminishing the depth of capabilities within the product.

Release 4.1 supports a Genetic Reinforcemen add-on package designed to solve problems whi go beyond the capabilities of supervised learning systems. This package is particularly suited to financial market timing, process modeling, and other situations where the training signal is not available with each example.

For more information on NeuralWorks Professional II/PLUS release 4.1, call us at 412-787-8222 or fax at 412-787-8220.

For More Information Circle No. 407

***These networks require a special license to use.*

NEURALWARE

process involved in the use of NETS consists of translating the problem into a format that provides for input/output pairs, designing a network configuration for the problem, and finally training the network with input/output pairs until an acceptable error is reached.

NETS enables the user to generate C code to implement the network loaded into the system. This enables the placement of networks as components, or subroutines, in other systems. In short, once a network performs satisfactorily, the "Generate C Code" option provides the means for creating a program separate from NETS to simulate the network. Other features include the following: files can be stored in binary or ASCII format, propagation from multiple inputs is permitted, bias values can be included, data can be scaled without writing scaling code, the network can be tested quickly and interactively from the main menu, and there are several options that enable the user to manipulate learning efficiency.

NETS is written in ANSI standard C language to be machine-independent. The Macintosh version (MSC-22108) includes code for both a graphical-user-interface version and a command-line-interface version. The machine-independent version (MSC-21588) includes only code for the command-line-interface version of NETS 3.0.

The Macintosh version requires a Macintosh II-series computer and has been successfully implemented under System 7. Four executable codes are included on diskettes: two for floating-point operations and two for integer arithmetic. It requires Think C 5.0 to compile. A minimum of 1 Mb of random-access memory is required for execution. Sample input files and executable codes for both the command-line version and the Macintosh user-interface version are provided on the distribution medium. The Macintosh version is available on a set of three 3.5-in. (8.89-cm), 800K diskettes in Macintosh format

The machine-independent version has been successfully implemented on an IBM PC-series-compatible computer running MS-DOS, a DEC VAX computer running VMS, a SunIPC computer running SunOS, and a CRAY Y-MP computer running UNICOS. Two executable codes for the IBM PC version are included on the MS-DOS distribution medium: one compiled for floating-point operations and one for integer arithmetic. The machine-independent version is available on a set of three 5.25-in. (13.34-cm), 360K diskettes in MS-DOS format (standard distribution medium) or a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge in UNIX tar format. NETS was developed in 1989 and updated in 1992.

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This program was written by Todd A. Phillips of **Johnson Space Center**. *For further information, Circle 31 on the TSP Request Card.*
MSC-22108

Mathematics and Information Sciences

Program Helps in Analysis of Failures

Failures and propagation thereof are represented graphically.

The Failure Environment Analysis Tool (FEAT) computer program has been developed to enable people to see and better

understand the effects of failures in a system. The user can select failures from either engineering schematic diagrams or digraph-model graphics (as defined below), and the effects or potential causes of the failures are highlighted in color on the same schematic-diagram or digraph representation.

FEAT uses digraph models to answer two questions: (1) What will happen to a system if a set of failure events occurs? and (2) What are the possible causes of a set of selected failures? FEAT helps design reviewers understand exactly what redundancies have been built into a system and where there is a need to protect weak parts of the system or remove them by redesign. The program is also useful in operations, where it can help identify causes of failure after they occur. Finally, FEAT is valuable in conceptual development and as a training aid, inasmuch as digraphs can identify weaknesses in scenarios as well as in hardware. A properly developed digraph reflects how the functions of a system deteriorate as failures accumulate. In cases of very-large-scale projects of the system-engineering type, FEAT may substantially reduce the costs of evaluation of designs, training, and learning how failures propagate through the system.

The first step in using FEAT is building (1) a digraph model and schematic diagram of the system to be analyzed and (2) any data-base files to be displayed. The digraph model, drawn in MacDraw II, consists of circles with associated text, arrows, and logic gates that represent the flow of failure through a system. These are grouped into components that a digraph interpreter can analyze.

The digraph engine processor is a multistep algorithm that performs transitive closure. It begins by building a series of phantom bridges or gates that allow accurate bidirectional processing of digraphs. The digraph is reduced to a pair of matrices: an AND matrix and an OR matrix. These matrices are built in the computer memory such that each row/column intersection in the matrix occupies only 1 bit. After the AND and OR matrices are constructed, there are three "math" phases: one to find "hidden singletons," one to "compress" the OR matrix, and one to find "hidden doubletons." In each phase, forward path tracing is used to determine how far a source of failure can travel downstream through the digraph.

The Failure Environment Analysis Tool is written using Macintosh Programmers Workshop C v3.1. Compilation with MPW C v3.2 or higher is required if using System 7. FEAT can be linked with CLIPS 5.0 (MSC-21927, available from COSMIC). The program can be run on any Macintosh computer that has enough random-access memory to handle the mathematical models; 2Mb or more is highly recommended. A color monitor is necessary to display the model results but not necessary for the preliminary development of the model and schematic diagram. A drawing package such as CLARIS MacDraw II 1.1v2, which can save in PICT format, is required to build the models. The standard distribution medium for FEAT is a set of two 3.5-in (8.89-cm) Macintosh-format diskettes. An electronic copy of the documentation is included on the program medium along with example digraph files. The program was developed in 1990.

Apple, Macintosh, and Macintosh Programmers Workshop C are registered trademarks of Apple Computer, Inc. MacDraw II is a trademark of CLARIS Corp.

This program was written by R. W. Stevenson, M. E. Austin, and J. G. Miller of Lockheed Engineering & Sciences Co. for **Johnson Space Center**. *For further information, Circle 102 on the TSP Request Card. MSC-21873*

Improved Nonequilibrium Algebraic Model of Turbulence

A blend of previous models predicts pressure distributions more accurately.

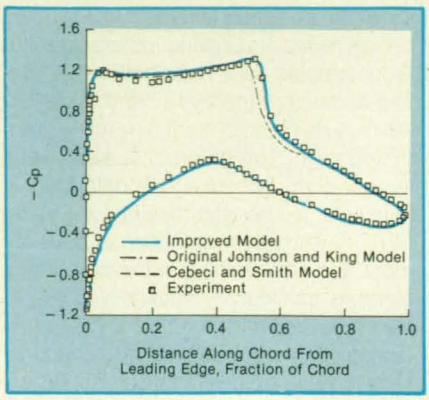
Ames Research Center, Moffett Field, California

An improved algebraic model represents some of the time-averaged effects of turbulence in the transonic flow of air over an airfoil. The improved model is a modified version of the Johnson and King nonequilibrium model.

The Johnson and King model has been shown to perform better than the equilibrium Cebeci and Smith mixing-length model and the equilibrium Baldwin and Lomax model for separated transonic flows about airfoils. However, in some experiments in which the shock waves on the upper surface of an airfoil were too weak to cause the flows to separate, the locations of the shocks were predicted better by the equilibrium models. In these cases, most of the differences between the predicted and observed locations of the shocks were attributed to a deficiency in the eddy-viscosity formulation of the Johnson and King model.

The improved model overcomes this deficiency. It satisfies the law of the wall (which expresses the average velocity as a function of distance from a wall) in the presence of adverse gradients of pressure better than either the original Johnson and King model or mixing-length theory does. It incorporates effects of compressibility and yields better predictions of skin friction in the presence of zero and favorable gradients of pressure.

The improved model is based partly on comparisons among various eddy-viscosity formulations for turbulence and partly on the premise that the law of the wall is more universally valid in the immediate region of the surface in the presence of an adverse gradient of pressure than the mixing-length theory and the original Johnson and King model are. The improved model essentially reduces to the original Johnson and King model when separation occurs.



Coefficients of Pressure in a mach-0.73 flow of air over an airfoil were measured and predicted by use of three different mathematical models of turbulence.

It involves the prescription of an algebraic velocity scale that, in effect, blends the eddy-viscosity relationships of the Clauser model (which uses the friction velocity as the velocity scale) with the eddy-viscosity relationships of the original Johnson and King model. To improve predictions of skin friction at zero and favorable gradients, the Johnson and King model is modified further by (1) use of a hyperbolic tangent (in place of an exponential) to blend the inner and outer distributions of eddy viscosity and (2) the use, in the Van Driest damping term, of a velocity scale modified to include the effect of compressibility.

The predictions of the improved model, of the original Johnson and King model, and of the Cebeci–Smith model were compared with experimental data for a mach-0.73 flow of air over an RAE 2822 airfoil at an angle of attack of 2.8°. As the figure shows, the distribution of pressure predicted by the improved model lies closest to the experimental data points.

This work was done by D. A. Johnson and T. J. Coakley of **Ames Research Center**. *For further information, Circle 23 on the TSP Request Card.*
ARC-12613

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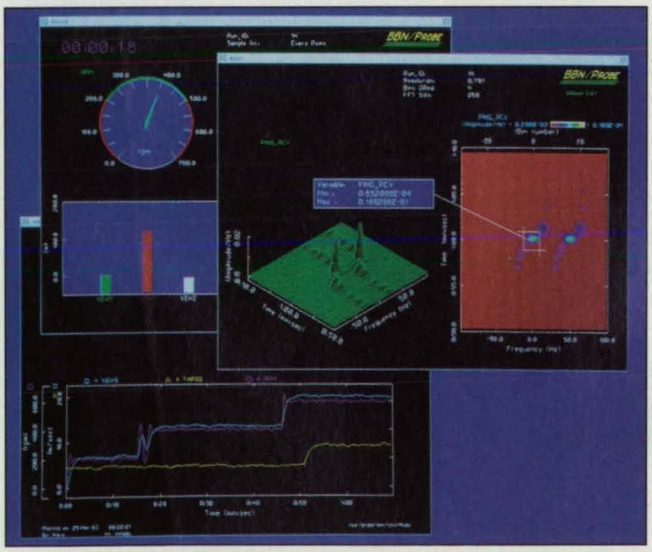

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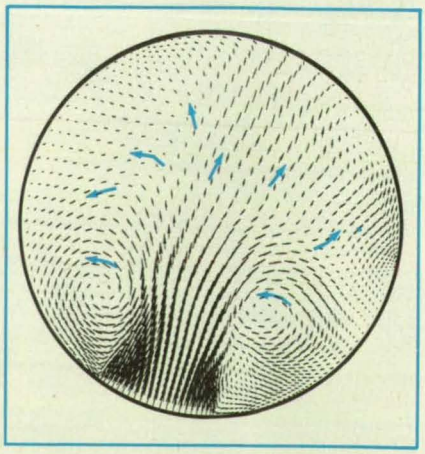
Ames Research Center, Moffett Field, California

An algorithm numerically integrates the Navier–Stokes equations of time-dependent or steady flow of an incompressible, viscous fluid. The algorithm can simulate realistic three-dimensional flows bounded by stationary or moving surface(s) of complicated shape(s). The algorithm was described to some extent in "Numerical Simulation of Flow Through an Artificial Heart" (ARC-12478), *NASA Tech Briefs*, Vol. 15, No. 12 (December 1991), page 66.

The derivation of the algorithm begins with the Navier–Stokes equations in primitive-variable form, using the pressure and velocity as the dependent variables. The equations are transformed into generalized curvilinear coordinates, which can be made to conform to complicated shapes. The transformed equations are reformulated according to the artificial-compressibility method, in which the derivative of pressure with respect to time is added to the equation of continuity. This couples the pressure and velocity fields, forming a hyperbolic system of equations that can be marched in pseudotime to a steady-state solution or subiterated in pseudotime at each step of physically realistic time to obtain a time-dependent solution.

The convective-flux terms of the hyperbolic system of equations are treated by an upwind-differencing scheme, which makes the system of equations more nearly diagonally dominant than it would be if a central-differencing scheme were used, and unlike a central differencing scheme, the upwind scheme does not require the specification of artificial-dissipation parameters to assure numerical stability. The convective-flux terms are split, according to a high-order flux-difference-splitting scheme, into terms that are biased by the signs of the local flux Jacobians: this is done by casting the equations in characteristic form, then forming the differencing stencil in such a way that it accounts for the directions of propagation of waves.

The resulting system of equations is solved by use of an unfactored-line-relaxation implicit numerical-integration scheme. This scheme allows the use of very large pseudotime steps, thereby leading to rapid convergence for steady flows and for the subiterations of time-dependent flows. The user specifies the number of line-relaxation sweeps. The only other parameter that the user has to specify is the artificial com-



The **Motion of Fluid Entering an Artificial Heart** in a plane through the center of the inflow valve was computed by the algorithm described in the text and is shown here as a plot of velocity vectors.

pressibility constant. For the most part, each of these two parameters can be specified independently; changing one does not usually force a large change in the optimum value of the other.

The algorithm has been tested by applying it to a number of steady and unsteady flows, including the flow in an artificial heart (see figure), which was discussed in the noted prior article. In all cases, the flows computed by this algorithm agreed well with analytical solutions and with experimental data where such data were available.

This work was done by Stuart E. Rogers of **Ames Research Center**. *Further information may be found in NASA TM-102199 [N91-15805], "Numerical Solution of the Incompressible Navier–Stokes Equations."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. ARC-13078

Synthesizing Friction in a Force-Reflecting Hand Controller

The controller resists motion with a limited force and holds its position when released.

Lyndon B. Johnson Space Center, Houston, Texas

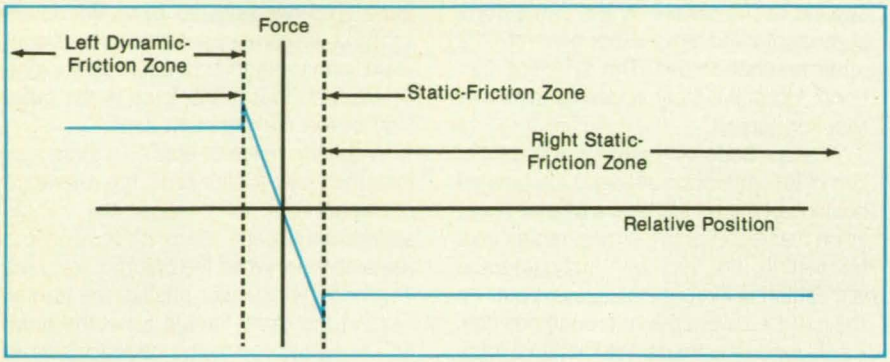
An algorithm synthesizes a frictionlike limited reaction force in a force-reflecting hand controller. The synthetic friction enhances the operator's feel and improves control characteristics in two ways: (1) the handle of the controller retains its setting when the operator releases it, and (2) in the case of a multiple-axis controller, the synthetic frictional force helps to hold the control setting on one axis when the handle is being pushed to command movement along another axis.

No additional equipment is needed to generate the synthetic frictional force. Instead, the synthetic-friction algorithm is incorporated into the hand-controller software, and the synthetic frictional force is applied to the handle by the same computer-controlled motors that generate the other reaction forces. The synthetic frictional force is simply added to the other reaction forces.

The synthetic frictional force is a function of the difference between the present position of the handle and a reference position that represents the most recent control setting. The synthetic frictional force is a centering force in that it always pushes the handle toward the reference position. As shown in the figure, the frictional force is specified in three zones: a static-friction middle zone with a springlike centering force, and two outlying dynamic-friction zones in which the centering force is constant, with a magnitude equal to or slightly less than that of the force at the outer limit of the static-friction zone.

When the operator applies a force less than the static-friction limit, the reference position does not change; the handle springs back to the reference position and remains there when the operator releases it. When the operator pushes the handle beyond the static-friction zone, the reaction force applied to the operator's hand

via the handle is the constant outer-zone dynamic frictional force, and the algorithm makes the reference position move along with the handle in such a way that the current, moving position of the handle lies at one of the outer boundaries of the static-friction zone. When the operator stops moving the handle, it springs back a short distance (through the relocated static-friction zone) to the relocated reference position and stays there until and unless pushed to a new position.



The **Synthetic Frictional Force** along one axis is a simplified version of a typical real frictional force, with a wider-than-natural static-friction zone in the middle.

This work was done by James Kauffman of Honeywell, Inc., for **Johnson Space Center**. *For further information, Circle 88 on the TSP Request Card.*
MSC-21932

Computing Vibration-Mode Matrices From Finite-Element Output

Postprocessing yields inertia matrices and elastic/rigid-coupling matrices.

NASA's Jet Propulsion Laboratory, Pasadena, California

Postprocessing algorithms have been devised to facilitate vibrational-mode analyses of the dynamics of complicated structures. Such analyses are important in simulation and control — for example, in active suppression of vibrations in a large building or in precise aiming of a large antenna.

Effective modal masses and moments of inertia, and their components associated with particular coordinate axes, provide insight into the characteristics of particular vibratory modes. Simplifications of procedures for the analysis of the transient dynamics of the structure can be facilitated by the convenience of identifying modes that involve relatively insignificant masses or inertias associated with the coordinate axis of interest. Such modes are candidates for elimination from the mathematical model of the dynamics of the structure and replacement by contributions to residual masses or inertias.

One of the postprocessing algorithms uses the eigenvalue-analysis output of a finite-element computation of the dynamic behavior of a structure to compute a matrix that represents the coupling between the rigid-body and elastic-body modes of the structure. Another of the

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postprocessing algorithms uses this elastic/rigid-coupling matrix to compute the modal contributions to the rigid-body mass matrix (which contains masses and moments of inertia) and to the effective modal masses and moments of inertia. These algorithms are adapted to use the eigenvalue-analysis output JPL-IDEAS and NASTRAN finite-element programs, without need to modify those programs. A third algorithm recomputes the elastic/rigid-coupling matrix in response to a change in the origin of the coordinate system.

This work was done by Roy Levy of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 52 on the TSP Request Card.*
NPO-18775

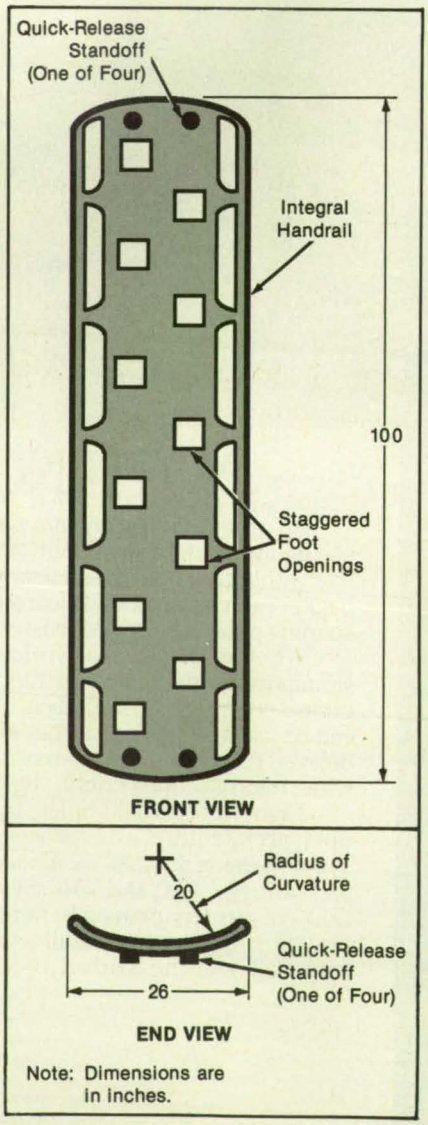
Versatile Lightweight Ladder

This device could also be used as stretcher or escape chute.

Langley Research Center, Hampton, Virginia

A proposed multipurpose escape-and-rescue device would be primarily a ladder but could also be used as an escape chute, stretcher, or float. The ladder would be fabricated as a single composite piece, with staggered openings for the feet and an integral handrail (see figure). In comparison with the rungs of a conventional ladder, the foot openings in this ladder would be designed to be less likely to cause injuries by jamming one's hands, arms, and legs between the ladder and the structure on which it was mounted. Quick-release fasteners would be used for mounting.

The ladder would be concave toward the user, with a radius of curvature of 20 in. (51 cm), as viewed along its major axis from an end. This curvature would give headroom when the ladder is stored overhead in the cabin of an airplane or helicopter, for example. Mounted this way, the ladder would also provide handholds for passengers and crewmembers to move about the cabin. The concavity of the ladder would also help prevent users from fall-



The **Ladder Would Contain Openings for Feet** instead of rungs and would include integral handrails.

ing off when it is used as a stretcher or as a slide for emergency egress.

The ladder could be made of a tempered aluminum core encapsulated in lightweight fireproof foam, with an exterior cover of three-ply bidirectional graphite/epoxy composite material. Of course, its dimensions and materials could be varied to suit specific applications. For example, titanium or balsa wood could be substituted for aluminum in the core. Small, flush-mounted lights could be embedded between the footsteps to guide users.

This work was done by Clarence F. Breen and John W. Fogle of **Langley Research Center** *and Ian O. MacConochie of Lockheed Engineering and Sciences Co. For further information, Circle 58 on the TSP Request Card.*
LAR-14631

Soft Sleeve Between Glove Box and Instrument

The sleeve protects the instrument from low frequency vibrations and helps maintain clean atmosphere for semiconductor analysis

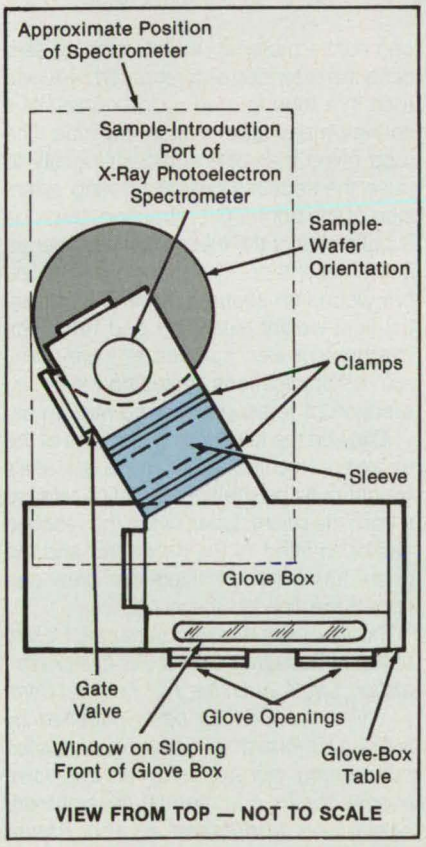
NASA's Jet Propulsion Laboratory, Pasadena, California

A soft, flexible sleeve (see figure) connects the interior of a glove box with the specimen-introduction port of an x-ray-photoelectron spectrometer. The sleeve, a soft, clean flexible rubber-backed Nylon, 0.010-in. (0.25-mm) thick, is made of the same material as that used in weather balloons. Its purpose is twofold: to isolate low-frequency vibrations of the glove box from the spectrometer and to protect the connection from the outside atmosphere and particulates.

The glove box enables a technician to load semiconductor samples into the spectrometer without contaminating them or the spectrometer. A continuous flow of nitrogen, maintained at low positive pressure inside the glove box, keeps the outside atmosphere from entering.

The sleeve presents a simple, inexpensive means to connect the glove box to the spectrometer, which in turn is mounted on an air suspension system to prevent low frequency vibrations of affecting data analysis from semiconductor samples.

This work was done by Frank Lombardi of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 51 on the TSP Request Card.*
NPO-17782



A **Flexible Sleeve** joins a glove box to the specimen-introduction port of an instrument chamber. The coupling is made of brown nylon with an inner layer of white rubber, attached to both areas with specially designed clamps. The thickness of the sleeve material is 0.01 in. (0.25 mm).

Lightweight Boom for Rescue Helicopter

The rescue harness is delivered within the pilot's view.

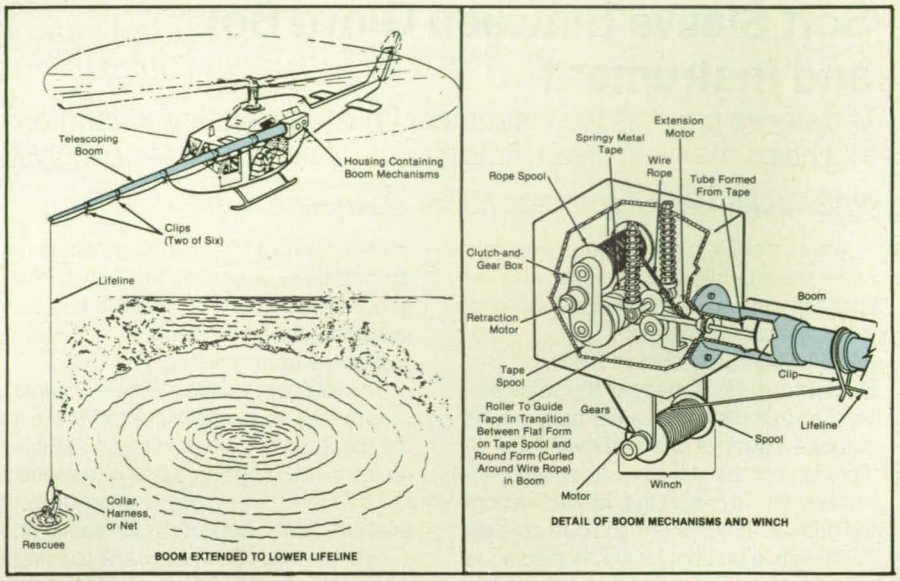
Ames Research Center, Moffett Field, California

A telescoping boom and associated mechanisms attached to a helicopter aid rescue operations by extending a lifeline beyond the sweep of the main rotor (see figure). The pilot can thus observe the rescuee and control the position of the helicopter more effectively than if the rescuee were directly below and hidden from the pilot's view. In addition, the rescuee is outside the downdraft of the rotor, which is often powerful enough to blow away or submerge someone in the water. The boom can be used for marine or land operations — for example, pulling people from the roof of a burning building.

The boom is thin and lightweight because it need not support the weight of the rescuee. Instead, the lifeline pulls away from the boom after it has been secured around the rescuee, who is then lifted directly into the cabin by a winch.

The boom is made of fiber-reinforced composite material. Its telescoping sections are extended and retracted by a wire rope in a tube formed by the curling of a springy metal tape around the rope. The tube gives the rope sufficient rigidity to push the sections outward during extension of the boom. On retraction, the rope is pulled out of the tube, which is flattened back into a tape. The tape and the rope are wound on separate reels. The potential light-weight extension and retraction mechanism also appears to have many spin-off applications, including the in situ erection of telescopic space structures.

Clips on the telescoping sections of the boom hold the lifeline. When the rescuee's weight pulls on the line, the clips release it from the boom. Later, when the rescuee has been lifted to the helicopter and the boom has been retracted, the crew can reload the line on the clips.



The **Tip of the Extended Boom** projects beyond the radius of the main rotor.

This work was done by Leonard A. Haslim of **Ames Research Center**. *For further information, Circle 24 on the TSP Request Card.*

This invention has been patented by NASA (U.S. Patent No. 5,020,742). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center [see page 24]. Refer to ARC-11909.

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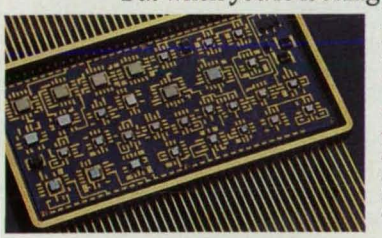

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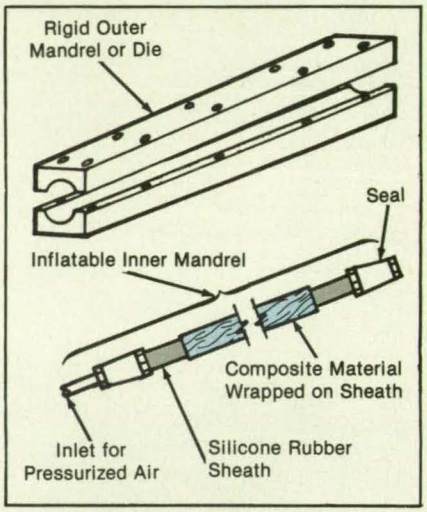
Adjustable-Pressure Mandrel for Making Composite Tubes

Both pressure and temperature can be set at desired levels for curing.

NASA's Jet Propulsion Laboratory, Pasadena, California

An inflatable inner mandrel enables the application of any desired pressure (within reasonable limits) during the curing stage in the fabrication of a fiber/matrix composite tube. Until now, most hand layups of composite tubes have been made by laying resin-impregnated fibers on rigid inner mandrels and placing them in outer mandrels. This technique requires that the layup be well debulked so that there is a very close tolerance between the inner and outer mandrels when the pieces are placed together. When the composite in such an assembly was heated to its curing temperature, the pressure applied by squeezing between the inner and outer mandrels was not directly controllable. This pressure depended on the curing temperature and the thermal expansions of the various materials in the assembly. As a result, the pressures generated during cure are not necessarily optimum or uniform throughout the interior of the tube, and the tube could therefore be weakened by voids and porosity.

The inflatable inner mandrel consists mainly of a sheath of silicone rubber sealed on an aluminum tube (see figure). The composite material is laid up on the mandrel and enclosed in a rigid outer die. The sheath on the inner mandrel is inflated to the requisite pressure and regulated during curing. The assembly is then placed in an oven and cured at the specified temperature.



Pressure Is Applied to a composite tube by an inflatable inner mandrel and a rigid outer mandrel.

This work was done by Paul J. Jacoy and Wesley P. Schmitigal of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 77 on the TSP Request Card. NPO-18587*

Feeder for Oxygen-Sensitive Powders

This feeder facilitates monitoring and transfer in an inert atmosphere.

Marshall Space Flight Center, Alabama

The figure shows a vessel designed to feed powders that must be protected against contamination by oxygen. The vessel has the following novel and advantageous features:

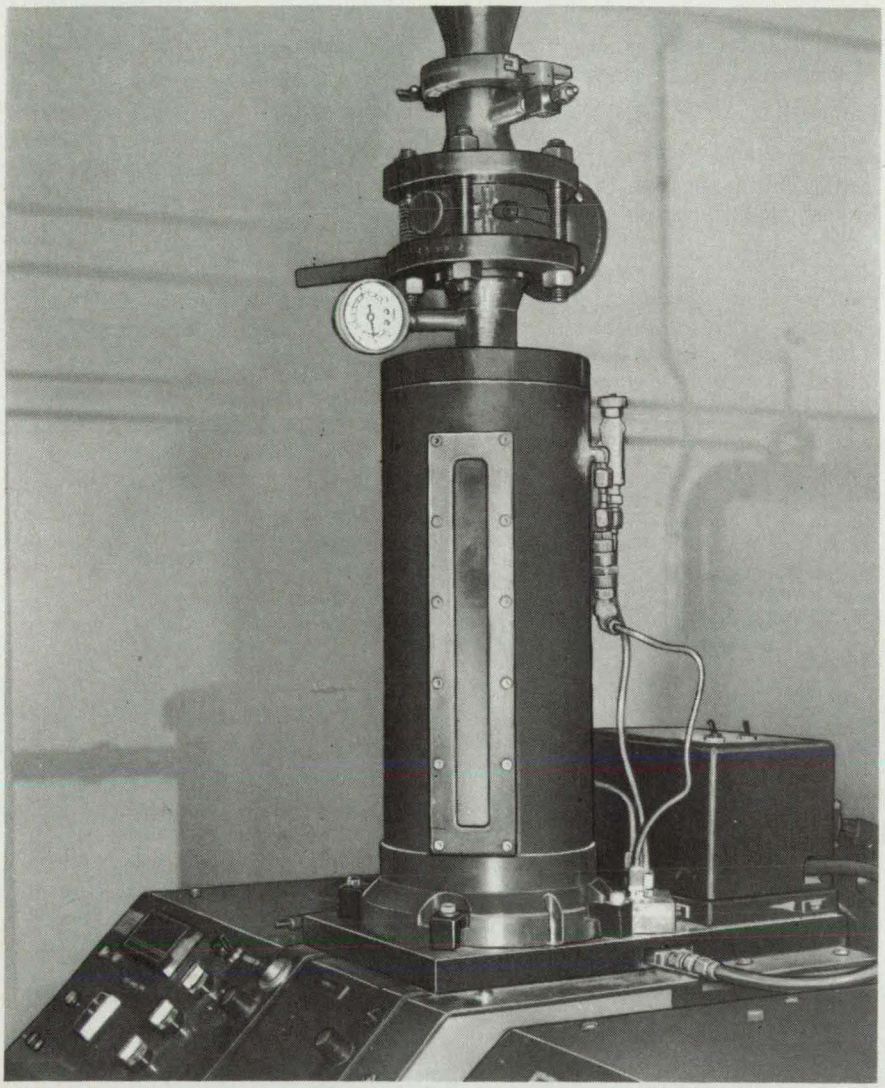
- A sight gauge enables the continuous monitoring of the level to which the feeder is filled with powder, as well as for visual monitoring of the quality (including the degree of oxidation) of the powder.
- A coupling mates with specially designed containers, in which powders are packaged under vacuum or inert gas. This eliminates the need for unnecessary handling of powders and the attendant risk of contamination by oxygen.
- An internal funnel enables the unloading of unused powder from the feeder in a vacuum or inert-gas atmosphere.
- A pressure gauge enables monitoring of

the pressure of the inert backfill gas.

The new feeder is made of stainless steel, 6061-T6 aluminum, and glass (for the sight gauge). It is equipped with a purge valve, filter, and pressure-relief valve. All internal surfaces have a finish of 16 μin. (0.41 μm), arithmetic average, and the feeder holds a vacuum of 10^{-4} torr (about 10^{-2} Pa).

This work was done by William H. Woodford, Timothy N. McKechnie, Christopher A. Power, and David H. Burns of Rockwell International Corp. for **Marshall Space Flight Center**. *For further information, Circle 18 on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-29857.



This **Powder Feeder** for oxygen-sensitive powders facilitates the transfer of powder while protecting it against oxidation.

Truss Slip Joint

Features include strength and relative simplicity of design and operation.

Marshall Space Flight Center, Alabama

The figure illustrates the two subassemblies of a slip joint for connecting truss members temporarily or permanently. It is designed to carry axial loads as large as

100,000 lb (450 kN) and to accommodate slight initial axial-displacement and angular misalignments. The joint can be assembled or disassembled by an astronaut in a space suit or, on Earth, by a technician in heavy protective clothing; it is even simple enough to be operable by a robot.

The end of the lower subassembly (see figure) has a conical outer surface that fits in a conical hole in the upper subassembly. A bolt is held in the upper subassembly by a snapring and is free to turn about the conical axis. A retaining plug on the bottom of the lower cone holds a nut, which is not free to turn, inside the lower subassembly.

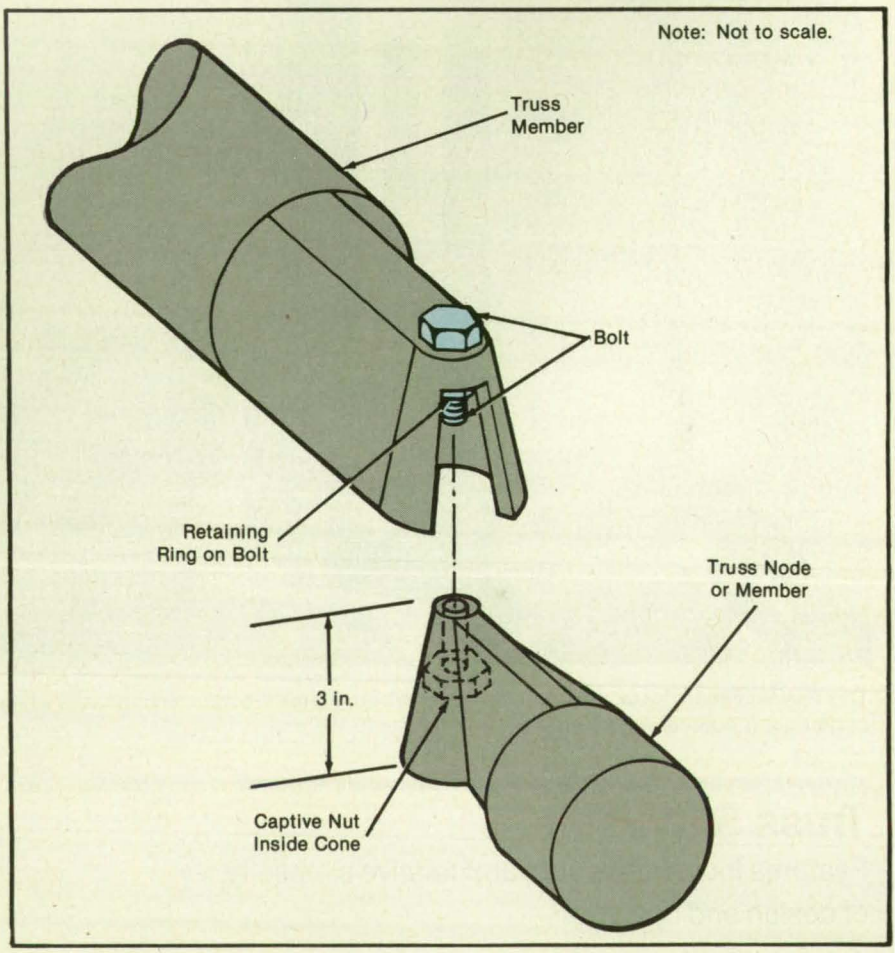
At the beginning of an assembly sequence, the mating conical surfaces of the upper and lower subassemblies are brought into proximity, and the bolt is turned to engage the nut. As the bolt is tightened, the two conical surfaces are forced together into load-bearing contact and alignment.

In comparison with most prior truss joints designed for the same applications, this one has fewer parts and is stronger. In addition, it can be modified to accommodate welding: a structure could be bolted together initially, then welded in the bolted configuration for extra strength and rigidity.

This work was done by Frank Thomas of **Marshall Space Flight Center**. *For further information, Circle 34 on the TSP Request Card. Further information may also be found in NASA TM-100395 [N90-22043], "Definition of Large Components Assembled On-Orbit and Robot Compatible Mechanical Joints."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-28659



The Truss Slip Joint has few parts, is strong, and can be assembled and disassembled easily.

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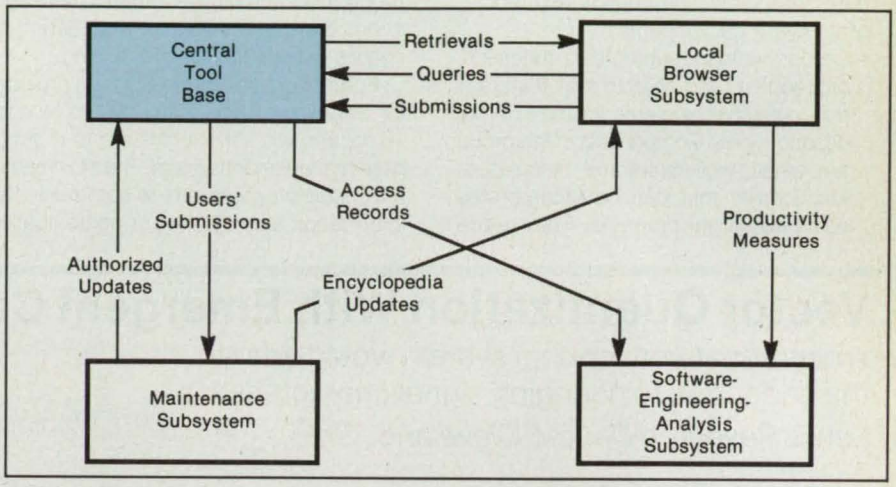
System for Retrieving Reusable Software

The system facilitates access to software components for rapid construction of prototype software.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Encyclopedia of Software Components (ESC) is an information-retrieval system of computer hardware and software that provides access to generic reusable software tools and parts. The ESC enables the rapid development of new software systems and is expected to reduce the cost of major software projects significantly.

With the ESC, a user can conveniently find and retrieve software through a hypertext interface (one that employs animation, audio, text, and graphics). Using the ESC is made to seem like going to a library; in fact, selections appear on a video display as a row of books. The user software developer first locates the general book category of interest, then selects a book and scans it, as though it were a standard reference work, to find previously written software that might satisfy some of the requirements upon the software to be developed. On finding the right software, the



The **Core of the ESC** is its central tool base, which is a repository of reusable software. It receives queries and submissions from the user through the local browser subsystem and receives authorized updates from the maintenance subsystem. It sends retrievals to the local browser subsystem and the user's submissions to the maintenance subsystem.

user can copy it into the new program.

The ESC can hold many software reference books, just as a library can contain a large collection. Users can create new reference books and place them in the ESC collection.

In its present version, the ESC supports the development of prototype application programs. The ESC is coupled with an experimental program that evaluates its effect on the productivity of the programmers who use it. It contains two groups of software components:

- Group 1 includes subroutines, functions, procedures, and objects that feature a minimum of entanglements and external dependencies. Components in this group are small, well-abstracted modules of functionality that can be incorporated easily into larger programs. They reside at the language-call level of use.
- Group 2 includes large stand-alone application programs that reside at the executive or shell level of use. Examples are screen-editor and system-utility programs.

A key feature is a local browser subsystem (see figure), which, as it is used, generates queries and submissions for the central tool base (which is the repository of reusable software). The local browser subsystem also generates measures of productivity and other evaluation data and sends them to a software-engineering-analysis subsystem for processing.

Future versions of the ESC will provide for advanced media, including voice and video, and will link the system to a data-base-management system. The new media will enable programmers to communicate information about software nontextually; for example, by computer animation and recorded verbal descriptions. With the help of the data-base-management system, the ESC will handle very large collections of reusable software and will facilitate the transfer of information about software and the development of software. In the ESC, graphical hypertext techniques will be integrated into the software-development environment. Programmers will be able not only to retrieve software, but also to modify it, execute it, and cross-link it with other software.

This work was done by Lloyd Van Warren and Brian C. Beckman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 7 on the TSP Request Card.*
NPO-18435

Vector Quantization With Emergent Codebook Structure

A neural-network coding system would adapt the codebook to changing signal characteristics.

Lewis Research Center, Cleveland, Ohio

In a proposed scheme currently under development for the transmission of vector-quantized digital video images, the vector quantizer codebook would be updated to adapt the quantizer to changing signal statistics. The scheme is intended to be realized with an electronic neural network. It is intended that the codebook, which consists of patterns

that constitute video images, will undergo training during operation and that the scheme should develop codebooks that are ordered during training.

As in prior vector-quantization schemes, (1) each codeword would represent all of the data values within a suitably small cluster of data and would be represented by an index; and (2) the vector that corresponds to each signal datum would be compared to all of the codewords and then the signal datum would be represented by the index of the codeword vector that is least distant according to a prescribed measure of distance in the vector space.

As in some prior vector quantization schemes, the codewords would be distributed in the abstract vector space in such a way that the statistics of the codeword distribution mimics the statistics of the video signal. When such a distribution is realized, it is likely that each succeeding codeword is in the neighborhood of the preceding codeword. If the indices are arranged so that codewords close in the distance measure are also close in Hamming distance, the locality between successive codewords can be exploited for three possible advantages. First, as in prior coding schemes, the locality can be used to realize a path-coding scheme. Path coding reduces the number of bits required to encode each vector by transmitting the change in the index rather than the full index. Second, the locality can be used in error-prone transmission channels to realize coders with increased noise immunity since bit errors that occur in the transmitted indices have limited distortion effects. And third, the locality can be exploited to realize variable-rate coders since index bits of less significance can be truncated at the transmitter and replaced at random at the receiver.

The proposed emergent scheme would implement the codeword ordering in a novel way derived from previous schemes. Each node of the neural network would represent a codeword. Each node would be topologically associated with n other codewords contained in the region that surrounds the node in the abstract data space. The region could be altered by changing the association threshold as the video signal characteristics changed. When it is determined that a training vector lies within the region of a particular node, called the winner, a portion of the n nodes associated with the winner node will be moved closer to the winner node while the remainder of the nodes in the region are moved farther from the winner. The winner will be selected based on both its proximity to the training vector and a measure of its utilization. By forcing the utilization of each codeword to be roughly equal, additional Huffman coding can be avoided.

The resulting codebook can be viewed as residing on a hypercube where edges of the hypercube are related by distortion; i.e., codewords that share edges would be close together in the abstract Euclidean space. The proposed system should enable coding to be more compact and more immune to noise, and should support variable rate compression.

This work was done by Stanley C. Ahalt and Ashok Krishnamurthy of Ohio State University for **Lewis Research Center**. *For further information, Circle 2 on the TSP Request Card.*
LEW-15130

Biochemical and Genetic Modification of Polysaccharides

Phage enzymes assist in the isolation, purification, and genetic modification of bacterial capsular polysaccharides.

NASA's Jet Propulsion Laboratory, Pasadena, California

Bacteriophages that produce endo-polysaccharase-type enzymes can be used to produce, isolate, and purify high yields of modified polysaccharides from the polysaccharides that are produced by, and incorporated into the capsules of, certain bacteria. More specifically, the bacteriophages can be used in the conversion of the native polysaccharide materials into polymers of nearly uniform high molecular weight or, alternatively, into highly pure oligosaccharides. The bacteriophages can also be used in the genetic selection of families of polysaccharides that are structurally related to native polysaccharide materials, but that have altered properties. The resulting new polysaccharides and oligosaccharides may prove useful in a variety of products, including pharmaceutical chemicals, coating materials, biologically active carbohydrates, and drag-reducing additives for fluids.

Heretofore, the synthesis of polysaccharides has been inhibited by (1) the high cost of separation of the polysaccharides from the bacteria and byproducts and (2) the limited ability to modify the molecular structures of native polysaccharides to enhance the properties of these polymers for specific uses. The method that involves the use of bacteriophages shows promise to overcome both inhibiting factors.

The method was demonstrated in experiments on the isolation of a drag-reducing polysaccharide from the K63 strain of the enteric bacterial species *Klebsiella pneumoniae*. The native (capsular) polysaccharide in these bacteria is approximately twice as effective in reducing drag as is xanthan gum, which is recognized as one of the most effective drag-reducing polymers. Without bacteriophage-enzyme treatment, it was found to be impossible to separate the capsular polysaccharide effectively, even in centrifugation at accelerations of 50,000 g (where g = standard gravitational acceleration at the surface of the Earth) for 4 h. However, a brief bacteriophage/enzyme treatment enabled separation of high-molecular-weight (about 3.5×10^6 daltons) polysaccharide material in 20 minutes of centrifugation at 6,000 g. Furthermore, the treatment led to an 80-percent increase in the amount of polysaccharide recovered.

As shown in the figure, further bacteriophage/enzymatic processing of the purified native polysaccharide under precisely controlled conditions leads to reproducible partial digestion into a homogeneous monodisperse polysaccharide that has an average molecular weight of 900,000 daltons. This material has been found to be suitable for the formation of films 25 nm thick. Alternatively, complete digestion of the native polysaccharide leads to a 64-percent yield of the basic repeating trimer (oligosaccharide). Gram quantities of the oligosaccharide sufficiently pure to crystallize

have been produced.

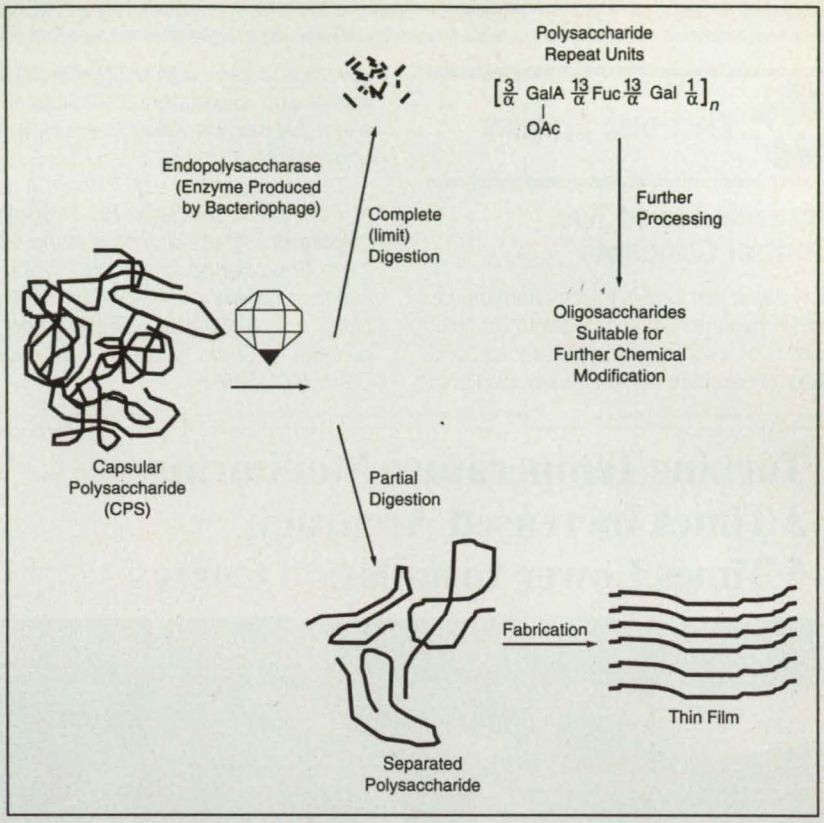
Enzyme-bearing bacteriophages that specifically infect *K. pneumoniae* K63 have been isolated and produced in large quantity. The ability of the endopolysaccharase of these bacteriophages to degrade the capsular polysaccharide of *K. pneumoniae* K63 specifically has been used as a selection tool to generate a family of polysaccharides with related structures. Among the bacteria that have been found to survive exposure to these bacteriophages are mutants, polysaccharides of which have altered molecular structures and, concomitantly, altered rheological properties. The altered polysaccharides have been found to be enzymatically convertible to oligosaccharides; thus, a new family of closely related structural oligomers has also been generated.

This work was done by Roger G. Kern, Gene R. Petersen, and Gil F. Richards of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, Circle 78 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

William T. Callaghan, Manager
Technology Commercialization
Jet Propulsion Laboratory
(M/S 301-350)
4800 Oak Grove Drive
Pasadena, CA 91109

Refer to NPO-18707, volume and number of this NASA Tech Briefs *issue, and the page number.*



The **Enzyme Produced by a Bacteriophage** is used to digest bacterial capsular polysaccharide. Digestion can be partial or complete, depending on the process conditions.

Books & Reports

These reports, studies and handbooks are available from NASA as Technical Support Packages (TSP's) when a Request Card number is cited; otherwise they are available from the National Technical Information Service.

Electronic Systems

Equivalence of Two Control Concepts

A paper discusses the relationship between two alternative concepts for force control of a robotic manipulator: second-order impedance control and proportional-gain explicit force control. It presents theoretical and experimental findings to the effect that the two concepts are essentially equivalent.

This work was done by Richard A. Volpe of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "The Equivalence of Second Order Impedance Control and Proportional Gain Explicit Force Control: Theory and Experiments," Circle 100 on the TSP Request Card. NPO-18619*

Eddy-Current Inspection of Graphite-Fiber Composites

A NASA technical memorandum describes initial research on, and the proposed development of, an automated system for the nondestructive eddy-current inspection of parts made of graphite-fiber/epoxy-matrix composite materials. The sensors in this system would be E-shaped or U-shaped eddy-current probes like those described in "Eddy-Current Probes for Inspecting Graphite-Fiber Composites" (MFS-26129), *NASA Tech Briefs*, Vol. 16, No. 5 (May 1992), page 20. According to the concept described briefly in that article, a robot would scan and rotate a probe over each part to be inspected while the probe is excited at suitable frequencies and the resulting impedance readings (as affected by the eddy currents in the parts) are processed into indications of flaws in the parts.

This work was done by G. L. Workman and C. C. Bryson of **Marshall Space Flight Center**. *Further information may be found in NASA TM-103514 [N91-10294], "Eddy Current Inspection of Graphite Fiber Composites."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 24]. Refer to MFS-27258.

Analysis of Delays in Simulation of Flight

A report presents an analysis of delays in the transport of signals through the various subsystems and components of a flight-simulation system. The analysis addresses all parts of the simulation process and system, from the analog-to-digital conversion and sampling of the pilot's command input, through multiple sampling rate digital processing via transfer-function mathematical models of the responses of the simulated aircraft and of the simulation system itself, to system output (e.g., the simulated motion of the aircraft and the simulated view of overflown terrain) sampled at the same rate as that of the pilot's command input.

This work was done by R. E. McFarland of **Ames Research Center** *and J. W. Bunnell of Syre, Inc. Further information may be found in AIAA paper A91-16719, "Analyzing Time Delays in a Flight Simulation Environment."*

Copies may be purchased [prepayment

required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500. ARC-13111

Physical Sciences

Comparison of Two Methods of Calibrating Polarimetric SAR

A report presents a comparative analysis of two approaches to the calibration of synthetic-aperture radar (SAR). The analysis is performed in the context of the NASA/JPL SAR system mounted in a DC-8 airplane but should also be applicable to any polarimetric SAR system of similar design. The analysis demonstrates the functional equivalence of the two approaches to calibration.

In one approach, known as Klein's approach, the SAR data to be calibrated are supplied in scattering-matrix format, and the algorithm that processes the data is based partly on two assumptions regarding the radar backscatter from natural targets; namely, (1) reciprocity between the cross-polarized components and (2) lack of correlation between like- and cross-polarized components. In the other approach, named after van Zyl, the SAR data to be calibrated are supplied in Stokes-matrix (compressed) format, and the algorithm that processes the data is based partly on the assumption of reciprocity between the *R* and *T* matrices, which represent the polarimetric characteristics of the receiving and transmitting subsystems, respectively, of the radar system. Both approaches require one or more trihedral corner reflectors (as targets that have known radar-backscatter characteristics) within the scene from which the SAR data are taken.

This work was done by Anthony Freeman, Jakob J. van Zyl, Jeffrey Klein, Howard A. Zebker, and Yuhsyen Shen of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Calibration of Stokes and Scattering Matrix Format Polarimetric SAR Data," Circle 104 on the TSP Request Card.*
NPO-18496

Electrostatic Propulsion Using C_{60} Molecules

A report proposes the use of C_{60} as the propellant material in the electrostatic propulsion system of a spacecraft. C_{60}, C_{70}, and similar molecules, known as fullerenes because their isosahedral structures are reminiscent of the geodesic domes invented by R. Buckminster Fuller, have recently been found to have characteristics that could prove advantageous in electrostatic propulsion. The report discusses these characteristics and proposes experiments to determine the feasibility of the concept.

This work was done by Stephanie D. Leifer and Winston A. Saunders of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Electric Propulsion Using C_{60} Molecules," Circle 22 on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Edward Ansell
Director of Patents and Licensing
Mail Stop 305-6
California Institute of Technology
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Pasadena, CA 91125

Refer to NPO-18526, volume and number of this **NASA Tech Briefs**, *and the page number.*

Experiments on Flow in a Coronary Artery

A report describes experiments on the simulated flow of blood in an atherosclerotic human coronary artery. The experiments were performed on a polyurethane cast made from the S-shaped coronary artery of a cadaver. A sucrose solution with the viscosity of blood was pumped through the cast at physiologically realistic rates, and

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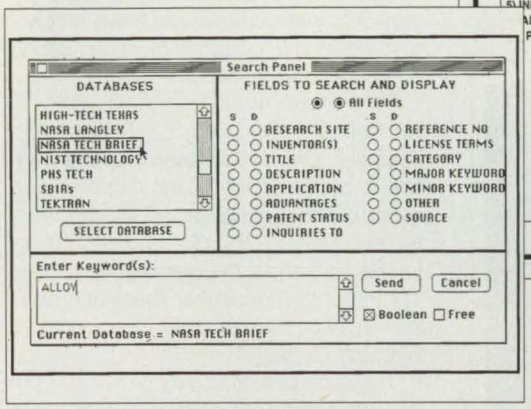

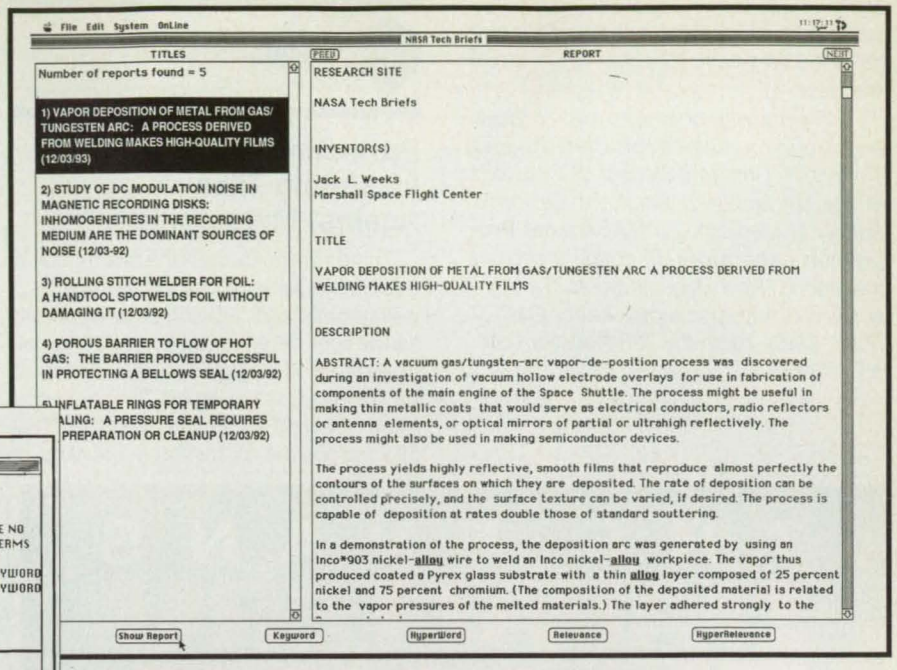

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the flow was made pulsatile by a mechanism that alternately compressed and released an elastic tube just upstream of the cast.

This work was done by Lloyd H. Back and Eug-Yon Kwack of Caltech and Timothy K. Liem and Donald W. Crawford of the University of Southern California School of Medicine for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Flow Measurements in a Highly Curved Atherosclerotic Artery Cast of Man," Circle 70 on the TSP Request Card. NPO-18426*

Materials

Protecting Spacecraft-Insulating Tiles Against Meteoroids

Three reports discuss the problem of reducing the damage caused by impacts of meteoroids and orbiting debris on the lightweight ceramic outer insulating tiles of spacecraft destined to reenter the atmosphere. The first report, "Impact Hardened Thermal Protection System (TPS) Tile," proposes to reinforce the tiles by embedding multiple spaced layers of ceramic cloth in them.

The second report, "Hypervelocity Impact Testing of Shuttle Orbiter Thermal Protection System Tiles," describes experiments designed to simulate impacts of meteoroids on insulating tiles.

The third report, also called "Hypervelocity Impact Testing of Shuttle Orbiter Thermal Protection System Tiles," is in the format of lecture-presentation images. It includes excerpts and summaries of information from the two above-mentioned reports and from a prior report on multishock shielding. It also includes some x-ray energy-dispersive spectra obtained in scanning electron microscopy of impact debris described in the second report.

This work was done by Eric L. Christiansen, Burton G. Cour-Palais, and Jeanne L. Crews of **Johnson Space Center**. *To obtain copies of the first and third reports, "Impact Hardened Thermal Protection System (TPS) Tile" and the lecture-image version of "Hypervelocity Impact Testing of Shuttle Orbiter Thermal Protection System Tiles," Circle 55 on the TSP Request Card.*

Further information may be found in the second report, AIAA paper A91-10082, "Hypervelocity Impact Testing of Shuttle Orbiter Thermal Protection System Tiles."

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500. MSC-21846

Perfluorocarbons as Fire-Suppression Agents

A report describes research to evaluate perfluoroethane (C_2F_6), perfluoropropane (C_3F_8), and perfluoro-n-butane (C_4F_{10}) as replacements for Halon 1301 (bromotrifluoromethane, $CBrF_3$) as the working fluids in fire extinguishers. Because Halon 1301 has the potential to deplete the Earth's ozone layer, its production is scheduled to be ended by the year 2000.

This work was done by Philip J. DiNenno and Eric Forssell of Hughes Associates, Inc., for **Kennedy Space Center**. *To obtain a copy of the report, "Investigation of the Use of Perfluorocarbons as Fire Suppression Agents," Circle 19 on the TSP Request Card. KSC-11573*

Styrene-Terminated Polysulfone Oligomers as Matrix Materials

A report summarizes a preliminary experimental study and evaluation of styrene-terminated polysulfone oligomers as the matrix materials in graphite-fiber/matrix composites. The composites are evaluated in terms of methods of fabrication and of mechanical properties.

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This work was done by Kenneth J. Bowles and Raymond D. Vannucci of **Lewis Research Center** *and Dana Garcia of BF Goodrich Co. Further information may be found in NASA TM-89846 [N87-21043], "Styrene-Terminated Polysulfone Oligomers as Matrix Material for Graphite Reinforced Composites — An Initial Study."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-15338

Oxidation and Hot Corrosion of ODS Alloys

A report reviews the oxidation and hot corrosion of oxide-dispersion-strengthened (ODS) alloys, which are intended for use at high temperatures. The report concludes that these alloys, as a class, have better environmental resistance than do similar alloys without dispersion strengthening. The report classifies the environmental resistances of such alloys by rates of growth of oxides, volatilities of oxides, spalling of oxides, and limitations imposed by hot corrosion. Also discussed are environmentally resistant coatings for ODS materials. The report also concludes that ODS NiCrAl and FeCrAl alloys are highly resistant to oxidation and corrosion and can probably be used uncoated.

This work was done by Carl E. Lowell and Charles A. Barrett of **Lewis Research Center**. *Further information may be found in NASA TM-102555 [N90-25211], "The oxidation and corrosion of ODS alloys."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-15385

Applications of Graphite Fluoride Fibers in Outer Space

A report characterizes graphite fluoride fibers made from commercially available graphitized carbon fibers and discusses some potential applications of graphite fluoride fibers in outer space. These applications could include heat-sinking printed-circuit boards, solar concentrators, and absorption of radar waves. Other applications could be based on exploitation of its increased resistance (over that of graphite) to degradation by atomic oxygen, which is present in low orbits around the Earth.

This work was done by Ching-cheng Hung of **Lewis Research Center** *and Martin Long and Therese Dever of Cleveland State University. Further information may be found in NASA TM-103265 [N91-11062], "Graphite Fluoride Fibers and Their Applications in the Space Industry."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. LEW-15300

Mechanics

Development of a Navier-Stokes Computer Code

A report discusses aspects of the development of the CENS3D computer code, which solves the three-dimensional Navier–Stokes equations of compressible, viscous, unsteady flow. CENS3D implements an implicit finite-difference or finite-volume numerical-integration scheme, called "lower–upper symmetric-Gauss–Seidel" (LU-SGS), which offers the potential for very low computer time per iteration and for fast convergence.

This work was done by Seokkwan Yoon and Dochan Kwak of **Ames Research Center**. *Further information may be found in AIAA paper 91-1555, "An Implicit Three-Dimensional Navier–Stokes Solver for Compressible Flow."*

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More About Bridge Feedback and Active Damping of Vibrations

Two reports present additional details of a method of active suppression of vibrations in a truss structure. The method, which involves feedback to active truss members from collocated force and velocity sensors, was described in "Two Techniques for Suppressing Vibrations in Structures" (NPO-17889), *NASA Tech Briefs*, Vol. 15, No. 12 (December 1991), page 60.

This work was done by Gun-Shing Chen and Boris J. Lurie of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain copies of the reports, "A Frequency Domain Analysis for Active Damping Augmentation" and "Active Member Bridge Feedback Control for Damping Augmentation," Circle 62 on the TSP Request Card. NPO-18356*

Structures of Turbulent Boundary Layers

A report presents the second part of a two-part comprehensive study of coherent motions in, and structures of, turbulent boundary-layer flows. The study critically reviews the current fragmented knowledge with a view toward eventual unification and understanding of the physical causes and statistical properties of turbulence phe-

nomena. The first part of the study focuses on the definition of the state of knowledge of turbulence structures and the clarification of major unresolved issues. The second part, detailed in the report, is an effort to develop a conceptual model of the physics of boundary-layer turbulence that accounts for the known structural features and describes the kinematics of the production and dissipation of turbulence.

This work was done by Stephen K. Robinson of Langley Research Center while at **Ames Research Center**. *Further information may be found in NASA TM-103859 [N91-26465], "The Kinematics of Boundary Layer Structure."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
ARC-13160

Active Members Excite and Measure Vibrations in Trusses

A report describes an experimental study of the use of active structural members to excite and measure vibrations as small as microns in a truss structure. These experiments are part of a continuing effort to develop an active vibration-suppressing control system that would adapt itself to changing and/or partly unknown dynamical characteristics of a truss structure in outer space. Some aspects of the control concept and potential terrestrial applications were described in "Two Techniques for Suppressing Vibrations in Structures" (NPO-17889) *NASA Tech Briefs*, Vol. 15, No. 12 (December 1991), page 60.

This work was done by Chin-Po Kuo, Gun-Shing Chen, and Ben K. Wada of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "On-Orbit System Identification Using Active Members," Circle 98 on the TSP Request Card.*
NPO-18353

Computed Flows in a Transonic Turbine

A report presents a computational study of the flow in the first stage of three alternative versions of a proposed transonic turbine. Much better performance (lower weight, greater efficiency, greater power per stage, and the like) will be required of future turbines, necessitating increasing departures from established designs and design methods. To predict the performance and analyze the effects of changes in the designs of these advanced machines, it will be necessary to compute turbine flows by means that capture the essential features of their space- and time-varying complexity. This study demonstrates an application of computational fluid dynamics to such an analysis.

This work was done by A. A. Rangwalla and N. K. Madavan of Sterling Software and P. D. Johnson of Pratt and Whitney for **Ames Research Center**. *Further information may be found in AIAA paper A91-44254, "Application of an Unsteady Navier–Stokes Solver to Transonic Turbine Design."*

Copies may be purchased [prepayment required] from AIAA Technical Information Service Library, 555 West 57th Street, New York, New York 10019, Telephone No. (212) 247-6500.
ARC-13158

Robustness in Suppressing Vibrations With Adaptive Control

A report describes a theoretical and experimental study of the robustness of an adaptive model-reference control scheme designed to suppress vibrations in a large, flexible structure. The model in question can be a mathematical model or collection of models that approximate(s) the dynamics of the structure, vibration sensors, and vibration-suppressing actuators. As in prior studies performed by the same research group, the flexible structure used in the experiments resembles both a spider web and an antenna; it includes 12 flexible radial ribs connected to a hub along with 12 rib-root actuators and connected to each other by circumferential wires at 2 different radii.

This work was done by Che-Hang C. Ih, David S. Bayard, Asif Ahmed, and Shyh J. Wang of Caltech for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "Experimental Study of Robustness in Adaptive Control for Large Flexible Structures," Circle 97 on the TSP Request Card.*
NPO-18339

Free-Stream-Capturing Metrics

A report summarizes techniques for the preservation of free-stream flows in finite-volume and finite-difference flow computations that involve transformations between moving and stationary coordinates. These techniques are necessary for accurate computations of complicated flows; for example, to compute the flow about a helicopter rotor by use of a grid that conforms to and moves with the rotor blades.

This work was done by Shigeru Obayashi of MCAT Institute for **Ames Research Center**. *To obtain a copy of the report, "Free-Stream Capturing for Moving Coordinates in Three Dimensions," Circle 107 on the TSP Request Card.*
ARC-13122

Fabrication Technology

Inflatable Habitat Structure

A report describes a proposed inflatable habitat structure to be used during explora-

tion of the Moon or Mars. The structure would provide living and working space for 12 crewmembers and would include a horizontal cylindrical skin 8 m in diameter and 45 m long. The skin would enclose floors and an arch frame, which would be supported by an exostructure on foundations.

This work was done by Kriss J. Kennedy of **Johnson Space Center**. *To obtain a copy of the report, "Horizontal Inflatable Habitat for Lunar Surface Systems," Circle 94 on the TSP Request Card.*
MSC-22029

Mathematics and Information Sciences

Errors in Graphical Analysis of Computed Flows

A report discusses sources of error in the graphical display and analysis of flow fields simulated numerically by computers. Computer-graphical techniques are used widely to make selected aspects of simulated flow fields visible. The errors inherent in these techniques can result in imprecise depictions. An understanding of these errors is important for proper interpretation of computed flow-field data and for comparison of simulated with measured flow fields.

The sources of error are explored by way of examples of graphical techniques and the errors that they can introduce in the depiction of flow fields computed from the Reynolds-averaged Navier–Stokes equations. The specific graphical techniques examined are contouring, plotting arrows on pictures to represent three-dimensional vectors, and particle tracing (simulation of a stream of smoke or dye or tracing the path of a fictitious particle entrained in the simulated flow).

This work was done by Pieter Buning of **Ames Research Center**. *To obtain a copy of the report, "Sources of Error in the Graphical Analysis of CFD Results," Circle 68 on the TSP Request Card.*
ARC-13152

Life Sciences

Effect of Leg Exercise on Vascular Volumes During Bed Rest.

A report describes experiments on the effects of a no-exercise regimen and of two leg-exercise regimens on the volumes of plasma, the volumes of red blood cells, the densities of the bodies, and the water balances of 19 men (32 to 42 years old) confined to −6°-head-down bed rest for 30 days. The purpose of the study was to determine whether either or both exercise regimens would maintain plasma volume and to relate the levels of hypovolemia (low blood volume) to body fluid balances.

The men were divided into three groups: five on the no-exercise regimen, seven on a regimen of nearly maximal alternating isotonic exercise for 60 minutes each day, and seven on a regimen of nearly maximal intermittent isokinetic exercise for 60 minutes each day.

Analysis of the results showed that during bed rest, plasma volume was maintained in the isotomic group but not in the other two groups, and there were no significant differences in body densities, body weights, or water balances among the three groups. The authors conclude that the isotonic-exercise regimen is better than the isokinetic-exercise regimen for maintaining plasma volume during prolonged exposure to bed rest.

This work was done by J. E. Greenleaf and J. Vernikos of **Ames Research Center**, *C. E. Wade of Letterman Army Institute of Research, and P. R. Barnes of San Fancisco State University. To obtain a copy of the report, "Effects of Leg Exercise Training on Vascular Volumes During 30 Days of −6° Head-Down Bed Rest," Circle 5 on the TSP Request Card.*
ARC-12971

NASA Tech Briefs LITERATURE SPOTLIGHT

Free catalogs and literature for NASA Tech Briefs' readers. To order, circle the corresponding number on the Reader Action Request Form (page 81).

LAB/TEST OVENS BULLETIN

A 20-page catalog (Bulletin 3610) describes lab/test ovens by Applied Test Systems. Ovens available in box and split-box types, and standards plus custom ovens. Features include: stainless steel shell, uniform temperature, fast heat-up, low power consumption, low shell temperature, rigid construction, and temperatures from -300 °F to +1150 °F.

Applied Test Systems, Inc.

For More Information Circle No. 300

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Quatech Inc.

For More Information Circle No. 301

GPS TIMING FOR PC AND VMEbus

This information folder from Bancomm describes new PCbus and VMEbus board-level Global Positioning System (GPS) Satellite Receivers. These products provide world-wide precision time (100 nanosecond) and frequency (1 Part in 10E7) references inside the host computer.

Bancomm

For More Information Circle No. 302

OPTICAL REFERENCE CATALOG

Edmund Scientific's free 204-page, full-color annual reference catalog features one of the largest selections of precision optics and optical instruments, plus a complete line of components and accessories for both large volume OEM users as well as smaller research facilities and optical laboratories. It contains over 8,000 hard-to-find items including a large selection of magnifiers, magnets, microscopes, telescopes and accessories.

For More Information Circle No. 303

POLYMERS & ACRYLIC MONOMERS

A new, 12-page four-color brochure titled "Engineering Polymers and Acrylic Monomers." Included are polymers and monomers family of products, including Rilsan® 11 and 12 polyimides; Rilsan® powder coatings; Pebax® thermoplastic elastomer resins; Platamid® and Platherm® hot melt adhesives; Platilon® hot melt film; and acrylic monomers. Product description, background, and a sampling of applications are also provided.

Elf Atochem North America, Inc.

For More Information Circle No. 304

DATA ACQ. HARDWARE AND SOFTWARE

Free catalog showcases our line of turnkey PC-based data acquisition systems and new DI-200 Series plug-in cards. Our systems offer real-time display and disk streaming with playback and analysis. DI-200 products for DOS and Windows feature dual channel 16-bit DMA, with complete programmability including sample rate per channel. Prices start at $795. Call 800-533-9006.

Dataq Instruments

For More Information Circle No. 305

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The legendary Vector Fields suite of software, including the TOSCA, ELEKTRA, and OPERA packages, combines classical finite element techniques with user friendly interactive graphics for high accuracy 2D and 3D simulation and design of all types of electromagnetic equipment.

Vector Fields, Inc.

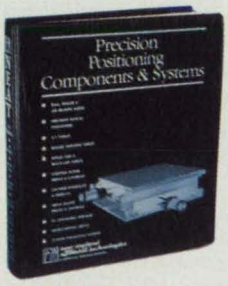
For More Information Circle No. 306

CATALOG DESCRIBES DATA ACQUISITION SYSTEMS

General and specialized data acquisition systems are described in this new catalog from Hi-Techniques. Modular in design, these products contain all the software for acquisition of signal data, calculation of data parameters, and output of finished documentation for research and routine test applications. Tel: 608-221-7500.

Hi-Techniques, Inc.

For More Information Circle No. 307



PRECISION POSITIONING AND MOTION CONTROLS

NEAT's 1993 catalog includes the latest additions to its family of precision positioning components and systems. Featured are single-axis, multi-axis, rotary, high-vacuum, and air bearing stages; plus a complementary line of stepping, servo, and linear motor drives and controls. Stage travels range to 30+ in. with repeatability of 1 micron, speeds to 80 in./sec., and resolutions to 5 nm. Our engineers use CAD/CAM machining facility to provide custom turnkey solutions for a wide spectrum of applications. Tel: 800-227-1066.

For More Information Circle No. 308

FREE ISSUE— *SCITECH JOURNAL*

Call for a free issue of the bimonthly journal of the MacSciTech Users Association. Other benefits: free consultations with Expert Panel, software archives, technical conferences, solution guides, and discounts on CD-ROMs, books, courses, products, and more. Macintosh Scientific and Technical Users Association, 49 Midgely Lane, Worcester, MA 01604. Tel: 508-755-5242; Fax: 508-795-1636.

Macintosh Scientific and Technical Users Association

For More Information Circle No. 309

NOISE CONTROL PRODUCTS

New color brochure describes SONEX and SONEX 1 sound-absorbing materials with patented shapes that control noise better than standard acoustical treatments. Brochure explains basic noise control techniques and presents many forms, sizes, and colors of SONEX products for industrial, office, and OEM noise control. Brochure shows applications and includes information on acoustical performance.

SONEX

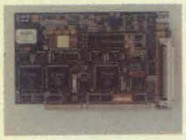
For More Information Circle No. 310

NEW SEAL SELECTION GUIDE

American Variseal announces their new guide for high-performance spring-energized seals. This unique eight-page, color manual, which describes Variseal's wide range of products for static, reciprocating and rotary service, utilizes highly functional charts and illustrations. Engineering charts include seal performance ratings at various pressures, temperatures, and speeds. Also included are data on seal materials, gland design and surface finish. Call 1-800-466-1727.

American Variseal

For More Information Circle No. 311



MIL-STD-1553/1773 PC INTERFACE

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Ponsor Corporation

For More Information Circle No. 312

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A complete 416-page engineer's guide with specifications, dimensions, and performance data presents brushless servos, microstepping motorsystems, indexers, linear motors and absolute encoders.

Compumotor Div., Parker Hannifin Corp.

For More Information Circle No. 313

STANDARD REFERENCE DATA CATALOG

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National Institute of Standards and Technology

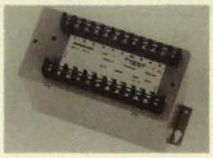
For More Information Circle No. 314

OPTICS FOR METROLOGY

This 106-page catalog gives information, including prices, on X-Y tables, microfinishing equipment, toolmakers' microscopes, alignment and monocular zoom microscopes, borescopes and miniborescopes, and fiber optic and miniature illumination systems. Also described are centering microscopes, optical cutting tool geometry analyzers, and more.

Titan Tool

For More Information Circle No. 315



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For More Information Circle No. 316

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Thaler Corporation

For More Information Circle No. 318

EXPANDED MECHANICAL COMPONENTS CATALOG

PIC Design, manufacturer of precision gears, pulleys, and many other mechanical components, has issued their biggest catalog yet. At 240 pages, Catalog 42 now includes a new section of Linear Motion products covering a range of precision lead screws, and precision ground shafting with associated support rails, hangers, and linear bearings. Tel: 203-758-8272; Fax: 203-758-8271.

PIC Design

For More Information Circle No. 319

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LaQue Center for Corrosion Technology, Inc.

For More Information Circle No. 320

FREE DATA ACQUISITION SOFTWARE TOOL

DAQ Designer helps determine which hardware and software combinations are best for your PC-based data acquisition system. DAQ Designer will (1) ask questions about your application, (2) analyze your answers to determine your system needs, and (3) describe what hardware and software you need. Tel: 1-800-433-3488 (US and Canada) or 512-794-0100; Fax: 512-794-8411.

National Instruments

For More Information Circle No. 321

TOOLING COMPONENTS & EQUIPMENT

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Reid Tool Supply Company

For More Information Circle No. 322

BATTERY HOLDERS

New expanded catalog of battery holders and accessories shows photographs, specs, and schematics as well as installation and design applications. Over 50 new products have been added such as large coin cell holders, terminal lugs, springs, and 9-volt battery snaps. For more information contact: Memory Protection Devices, 320 Broad Hollow Road, Farmingdale, NY 11735. Tel: 516-293-5891; Fax: 516-752-1971.

Memory Protection Devices

For More Information Circle No. 323

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Mildex Inc.

For More Information Circle No. 325

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AMCO Engineering Company

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For More Information Circle No. 327

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Western Graphtec, Inc.

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The 32-page, full-color Protector Glove Boxes Catalog describes Labconco's line of controlled atmosphere and multi-hazard glove boxes featuring one-piece or stainless steel liners.

Labconco Corp.

For More Information Circle No. 330

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AMCO Engineering Company

For More Information Circle No. 334

NEW 1993-94 TEMPERATURE MEASUREMENT AND CONTROL CATALOG

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For More Information Circle No. 335

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Galil Motion Control

For More Information Circle No. 336

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Systran Corp.

For More Information Circle No. 337

GPS-SYNCHRONIZED TIMING PRODUCTS

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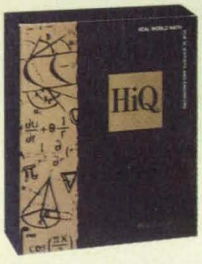
TrueTime, Inc.

For More Information Circle No. 338



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Stanford Research Systems

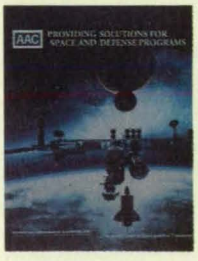
For More Information Circle No. 340

EMCOR'S GUIDE TO ENCLOSURES

This free catalog provides an overview of the Emcor product lines: ESQ, 10 Series, Emcor I, EMI-RFI, and CompuDesk. It also provides information on Instant Emcor and custom design. See Emcor at AFCEA. Emcor Products, 1600 4th Avenue NW, Rochester, MN 55901. Tel: 507-289-3371.

Emcor Products

For More Information Circle No. 341



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American Aerospace Controls

For More Information Circle No. 342

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For More Information Circle No. 343

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ThermaCal Inc.

For More Information Circle No. 344

RECIRCULATING CHILLERS

72-page catalog features a complete line of recirculating chillers for cooling water-cooled equipment. These chillers offer steady cooling with heat load removal up to 75 kW, spanning temperature ranges of -5 °C to +35 °C. Chillers feature LED display, operating status gauges, and easy access to internal components. Also available are Constant Temperature Bath/Circulators and Benchtop Personal Freezers. Call toll-free at 1-800-258-0830.

NESLAB Instruments, Inc.

For More Information Circle No. 345

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RGB Spectrum®

For More Information Circle No. 346

60-PAGE CATALOG OF INNOVATIVE DSP SYSTEMS

New 1993 catalog describes products for VMEbus and Multibus. Included are 15 models of single, dual and quad 'C40 processors, and triple DSP32C processors, 20 models of A/D and D/A converters; several models of digital I/O, T1/CEPT transceiver products, bus adapters, and many more. Software products include SwiftTools DSP development tools and SwiftNet network software. Tel: 201-767-7100; Fax: 201-767-3994.

Pentek, Inc.

For More Information Circle No. 347

WORKSTATIONS, LAB FURNITURE

20-page illustrated guide covers the Techlab line of technical work stations and laboratory systems furniture. Included are stations of different lengths, combined with a choice of cabinets, shelves, parts drawers, partitions, and other accessories. Catalog has dimensions, shows arrangements, describes work surfaces, and has color selection guide. Tel: 800-832-5227; Fax: 616-372-6116. Techlab, 6450 Valley Industrial Drive, Kalamazoo, MI 49009.

Techlab

For More Information Circle No. 348

DESIGN OPTIMIZATION SOFTWARE WITH FEA ENGINEERING BUILT-IN

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Algor, Inc.

For More Information Circle No. 349

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Kevex X-Ray, Inc.

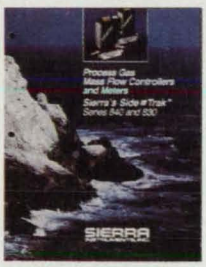
For More Information Circle No. 350

MERLIN DIGITAL FLIR-TO-VIDEO CONVERSION

Merlin Digital Scan Converters are used in critical applications ranging from medical imaging to on-board aircraft. A free brochure is available along with a technical paper describing the benefits of converting high line rate imaging to standard video prior to recording.

Merlin Engineering Works

For More Information Circle No. 351



PRECISION MASS FLOW CONTROLLERS

SIDE-TRAK monitors and controls the mass flow of air and process gases in ranges from 0-10 SCCM to 0-200 SCFM. The instrument delivers 1% FS accuracy, 0.15% repeatability and one second time response to set point changes. Patented access ports at both ends of the sensor tube reduce maintenance downtime.

Sierra Instruments, Inc.

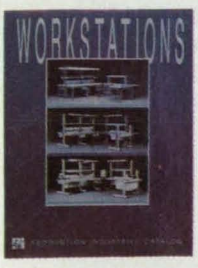
For More Information Circle No. 352

CFD FOR YOUR PC!

PC-PHOENICS, a full capability Computational Fluid Dynamics (CFD) code for PCs, provides accurate insight into fluid flow phenomena. Use your 386 or 486 to do everything a workstation or supercomputer will do, in customized, affordable versions to meet your needs. Free brochure.

Phoenics North America

For More Information Circle No. 353



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Production Industries has been a manufacturer of workstations for over 17 years. From cleanrooms to laboratories, packing tables to technician benches, Production Industries can provide a workstation that will fit your needs. For more information call us at (909) 272-0555. Let Production Industries' "commitment to quality" work for you!

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For More Information Circle No. 354

VERSATILE BORON NITRIDE

Combat® boron nitride is available in machinable solids, powders, coatings, and aerosol. Solids used as electrical insulators, high-temperature, non-wetting crucibles and fixtures, breakrings, and nozzles for molten-metal applications. Powders used as additives in plastics and cosmetics. Coatings used in metal, glass, and plastic industries for mold release and antioxidant.

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For More Information Circle No. 355

FastCAD-POWERPACKED WORKHORSE FOR CAD

FastCAD works for you! Save time and money with FastCAD's blazing speed and dynamic user interface. If you are serious about generating fast, detailed CAD drawings, call 1-800-874-4028 for a free hands-on demo disk.

Evolution Computing

For More Information Circle No. 356

MULTI-CHANNEL TRANSIENT ANALYZERS

The Nicolet MultiPro Transient Analyzer gives you all the inputs you need to handle two or 200 channel applications. These complete turnkey systems, which are up and running in minutes, are powerful and flexible, and use an easy-to-follow Microsoft® Windows™ environment.

Nicolet Measurement Instruments

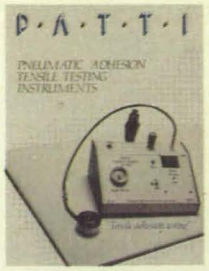
For More Information Circle No. 357

INVESTMENT CASTINGS

Your quality needs are our challenge. PMI brochure describes ferrous & non-ferrous investment castings to 10#. Many commercial & aerospace applications. 200 airmeltable alloys, with expanded capacity for ductile iron & aluminum. Near net-shape, internal complexity, close tolerances, excellent surface finish designed in. Engineering & prototype services complement your engineering team.

Precision Metalsmiths, Inc.

For More Information Circle No. 358



COATING ADHESION TESTER

PATTI measures adhesion tensile strength using compressed air to apply a continuous load to a 1/2" OD pull-stub bonded to the test coating. The maximum pressure is measured and converted to psi. Substrates may be flexible or rigid, flat or curved. Six piston ranges to choose from, up to 10,000 psi. Satisfies ASTM D4541 requirements.

SEMicro Corporation

For More Information Circle No. 359

LOW-COST VIBRATION TEST SYSTEMS

Vibration systems from 25 to 600 pounds force for: research and development; products qualification; vibration stress screening; modal excitation; vibration demonstrations. Also available: multiple shaker systems; table expanders; cube fixtures; custom fixtures; slip tables.

Vibration Test Systems

For More Information Circle No. 360

CCTV CAMERAS & SYSTEMS

A New Short Form Catalog features color and monochrome CCD cameras, including high performance, low light level and digital output models. Cohu cameras are designed and manufactured in the USA for security/surveillance and electronic imaging applications.

Cohu, Inc., Electronics Division

Security/surveillance applications: Circle No. 361
Electronic Imaging applications: Circle No. 362

B92 CATALOG RELEASE

The latest catalog from W.M. Berg Inc. coincides with Berg's silver anniversary. Founded in 1967, Berg has grown to become a recognized industrial leader of miniature precision mechanical components. A significant number of new items are added as well as expanding previous product lines. Featuring 50,000 standard components, 80% of which we are able to ship from stock within 24 hours. Available in metric version too: M92.

W.M. Berg, Inc.

For More Information Circle No. 363

OXYGEN ANALYZERS

A full-color brochure introduces a complete line of oxygen analyzers for the laboratory or process line. They are ideally suited for monitoring the oxygen levels in all types of gas streams. Trace oxygen levels from ppb to 100% are accurately determined by these ruggedly constructed instruments. No periodic maintenance or special operator skills are required. Intrinsically-safe and battery-operated models are also available.

Illinois Instruments Inc.

For More Information Circle No. 364

During 1993, CONTEC has added over 20 new products for PC-based Data Acquisition & Control. The NEW Product Guide covers CONTEC's range of boards, related software and accessories, **offering innovative solutions** for factory and lab automation. CALL FOR YOUR FREE COPY! Tel: **800-888-8884** or 408-434-6767 (8 to 5 Pacific Time); Fax: 408-434-6884. Address: 2188 Bering Drive, San Jose, CA 95131.

CONTEC Microelectronics USA Inc.

For More Information Circle No. 365

THE LINK BETWEEN COMPUTER GRAPHICS AND VIDEO

RGB/Videolink® video scan converters transform images from a computer, radar or FLIR sensor to broadcast standard video (NTSC or PAL) for taping, projection or teleconferencing. Video can be overlayed with computer generated graphics. Applications include training, simulation, archiving and signal transmission. GSA Contract #GS03F2032A.

RGB Spectrum

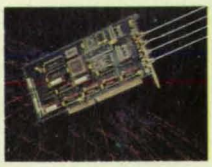
For More Information Circle No. 366

HOLLOW SHAFT INCREMENTAL ENCODER

BEI's new RIH22 hollow shaft encoder employs the latest in ASIC technology and features a stainless steel hollow shaft that accepts standard sizes to 1/2". The 2.2" dia. optical encoder provides resolutions to 5000 cpt, industrial-grade bearings, and a tether mounting plate. Output is in quadrature square wave with index. Differential and high voltage line drivers are available. Tel: 818-341-6161; Fax: 818-882-4553.

BEI Motion Systems Co.,
Chatsworth Encoder Division

For More Information Circle No. 367



HIGH SPEED DATA ACQUISITION CARD

TransEra announces its powerful 430 data acquisition card. The 430 card boasts a 125K sampling rate, 14 bit resolution, programmable gains and analog triggering.

TransEra Corporation

For More Information Circle No. 369

ENGINEERING ANALYSIS SOFTWARE

Xmath is a mathematical analysis and graphics environment for X Window workstations. Engineering applications include control systems design, test data analysis, and signal processing. Xmath combines numerical algorithms, interactive 2-D & 3-D graphics, and a programmable Graphical User Interface (GUI) designed by Prof. Stephen Boyd and Dr. Craig Barratt. Tel: 800-932-MATH; Fax: 408-980-0400, or demo Xmath on SunSoft's CDWare Vol. 4.

Integrated Systems, Inc.

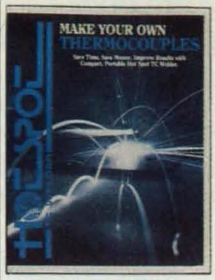
For More Information Circle No. 370

FIBER OPTIC INTERCONNECTS

New 6-page brochure details complete Packard Hughes high performance fiber optic interconnect line, all featuring patented self-aligning low-loss termini for superior optical performance. Includes solutions for multi-channel, rugged environmental and high-vibration environments, active optical interconnects, board-mounted connectors and more. For more information contact: Packard Hughes Interconnect, 17150 Von Karman Ave., Irvine, CA 92714. Tel: 714-660-5772.

Packard Hughes Interconnect

For More Information Circle No. 371



THERMOCOUPLES, MAKE YOUR OWN

The HOTSPOT allows thermocouple wire to be formed into freestanding junctions, or welded to metal surfaces. It provides a simple means of fabricating thermocouples "when needed and where needed." Brochure and specification sheet available. Address: 7300 North Crescent Blvd., Pennsauken, NJ 08110. Tel: 609-662-7272; Fax: 609-662-7862.

DCC Corp.

For More Information Circle No. 372

COMPACT CONTROLLERS FOR MACHINE/ PROCESS CONTROL

ANAFAZE CLS™ are versatile, inexpensive, 4, 8, and 16 multi-loop PID controllers to run small processes, experiments, machines. Key features: Autotune (Instant Set-up); accepts most sensor input types (even Infrared); 50 Digital I/O for alarms, events, triggers; computer I/O/Network features. New brochure free! Tel: 408-479-0415; Fax: 408-479-0526.

Anafaze

For More Information Circle No. 373

ZERO GUARDIAN EXTRA DUTY CABINET BROCHURE

Here is the only custom electronic cabinet without custom fees and no extra tooling charges. Tell us what size and features you need. We'll design and ship within 6 weeks! There are no fixed width, base or vertical wall dimensions if you stay in our min-max guidelines! Need EMI shielding or ruggedized capability? or protection from shock, vibration, water, fungus and temperature extremes? Brochure highlights design features and suggested applications.

Zero Corporation

For More Information Circle No. 374

PCB DESIGN & FABRICATION

Pentaplex's Printed Circuit Board design and fabrication capabilities are explained in this brochure and information insert: 24 hour service available. Prototypes. Surface Mount Technology. Flex Circuits. Double Sided or Multilayer boards. Teflon, Kapton and other materials. Fast turnaround specialists. Call 708-741-1120 or fax 708-741-1470 for information or quotes.

Pentaplex

For More Information Circle No. 375

COMPACT MeV MATERIALS ANALYSIS

This brochure describes the MAS1000 analysis instrument, which performs elemental analysis, depth profiling and channeling in crystals. In most cases the analysis is non-destructive and quantitative. The brochure describes the capabilities of standard RBS analysis as well as other analytical techniques capable with the MAS1000.

National Electrostatics Corp.

For More Information Circle No. 376

ABRASIVE BLAST SYSTEM

The Micro-Jet 200 is a miniature, low-cost system for the shockless machining, cutting, and etching of the hardest materials such as glass, ceramics, gem stones, carbides. Employing a pressure feed system for producing the air/abrasive jet, its operational performance is the equal of more expensive competitive systems. Applications include: cutting, drilling and shaping; etching and marking; micro-deburring and deflashing; cleaning; surface finishing.

Hunter Products, Inc.

For More Information Circle No. 377

ADVANCED COMPOSITE WORKSHOPS

The brochure describes nine different "hands-on" workshops in advanced composite materials technology. They cover fabrication, repair, tooling, blueprint reading, adhesive bonding, engineering design for specialized repairs, and ultrasonic inspection of composites. Emphasis is on prepreg carbon and aramid fiber material and processes, utilizing vacuum bagging and high-temperature curing methods. Tel: 800-638-8441; Fax: 702-827-6599.

Abaris Training Resources

For More Information Circle No. 378

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For More Information Circle No. 379

NEW CASES CATALOG

Zero Plastics' new catalog features their complete offering of standard and custom plastic thermoformed and rotationally molded cases for commercial and military applications. Full illustrations and color photographs highlight design features, benefits, suggested applications, and available accessories and options as well as technical data, specifications, and ordering information. Zero Plastics, A Unit of Zero Corp., 288 Main St., Monson, MA 01057.

Zero Plastics

For More Information Circle No. 380

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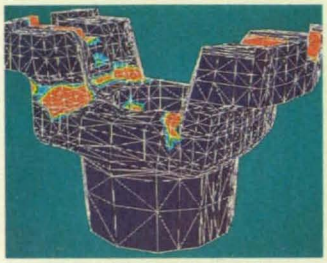
For More Information Circle No. 381

New on the Market

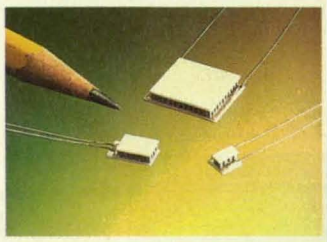


Algor Inc., Pittsburgh, PA, has announced Hypergen, the first **mechanical design software** that automatically generates solid meshes from a CAD representation of a surface mesh. The program shortens the time required to divide design models into finite elements, improving modeling efficiency and accuracy. Hypergen can import and export to a broad range of CAD/CAM systems, including those from Parametric Technologies, Computervision, Autodesk, Aries Technology, IBM, SDRC, and Intergraph.
For More Information Circle No. 567

Magnavox Electronic Systems Co., Torrance, CA, has introduced a 12-channel differential **GPS reference station** designed to provide high-precision, real-time submeter navigation and positioning. The MX 9112 tracks the navigation message and carrier frequency simultaneously for all satellites in view. As a reference station, it measures GPS signal errors, calculates correction factors, and broadcasts them to mobile GPS navigation receivers.
For More Information Circle No. 571

The Design Advisor Neural Analyzer (DANA™), a DOS-based **software** program from NeuralWare Inc., Pittsburgh, PA, provides the process engineer with a pocket calculator to support continuous chemical processing plant operations. DANA solves problems in composition inferencing, process-modeling, local set-point optimization, product formulation, and operator training.
For More Information Circle No. 572

Flow sensors manufactured by TURCK Inc., Minneapolis, MN, feature a unique omni-directional design to monitor gases and liquids flowing in any direction and respond rapidly to flow changes. Operating on the calorimetric principle, the highly reliable sensors have no moving parts and automatically compensate for changes in operating temperature. They are suitable for monitoring refrigeration systems, run-dry protection for conveyor pumps, and coolant in motors and drives.
For More Information Circle No. 568

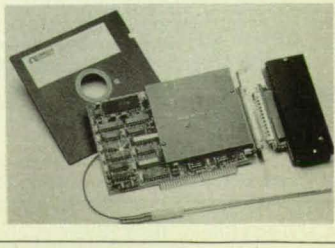


Pictured above are compact **thermoelectric cooling devices** for applications where packaging space is limited and low-current operation is needed. Introduced by Melcor, Trenton, NJ, the Frigichip®FC0.65 series modules are rated at 2 amps maximum and are available with 4 to 66 couples. The series comprises 17 modules with heat pump ratings from 0.54 to 8.89 watts.
For More Information Circle No. 573

Type 4-130 **vibration transducers** from CEC Instruments Division, San Dimas, CA, employ a unique bearing system to extend typical service life to 12,000 hours. They operate from -54 °C to 371 °C, with a dynamic operating range of 30 to 1500 Hz, and acceleration from 0.35g to 50g peak. Sensitivities from 60 to 145 MV/in/sec are available.
For More Information Circle No. 569

The CCD-1000, a high-resolution **video CCD camera** from Saguaro Scientific Corp., Tuscon, AZ, operates at video frame rates and features a 1260 x 1152 pixel imaging area covering 13.9 x 7.8 mm. It provides a signal-to-noise ratio of 40 dB at 1.5 lux and up to 10 bits of dynamic range. Video gain, shutter speed, and image integration can be controlled via an RS-232 interface.
For More Information Circle No. 574

OMEGA Engineering Inc., Stamford, CT, has unveiled the OMD-5508 series of **plug-in data acquisition cards** for thermocouples, RTDs, and strain gauges. Made to simplify signal connection and eliminate cabling costs, each I/O module has a removable screw panel that mates with a PC's board connector.
For More Information Circle No. 570



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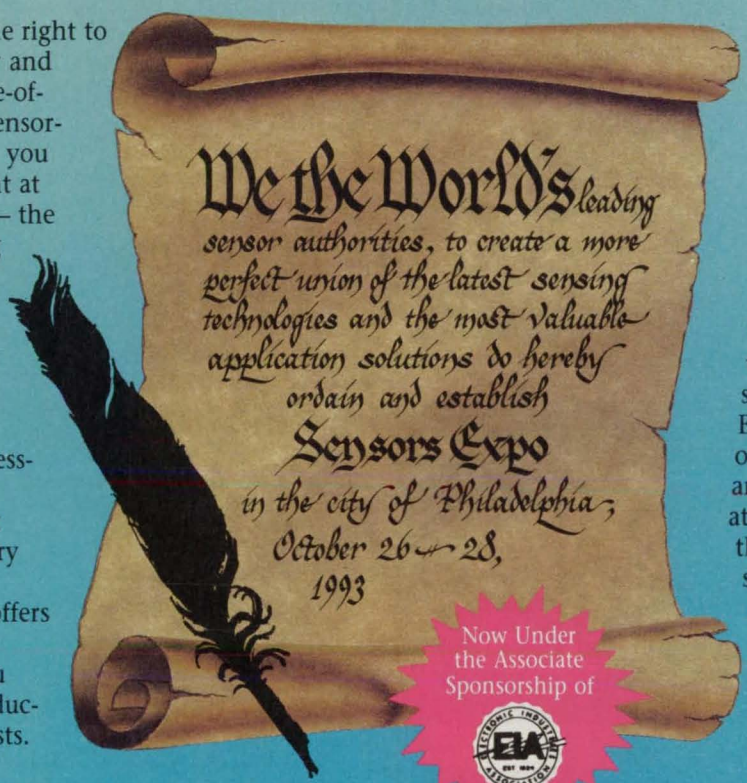

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A

New on the Market

Sharp Electronics Corporation, Camas, WA, has produced a 64K by 18-bit **static random access memory (SRAM)** designed to reduce noise, lower chip counts, and simplify circuitry in complex systems. The LH521028 suppresses ground bounce and other noise problems associated with fast, wide-word memory parts via six ground pins and six power pins distributed around its 52-pin PLCC package. It incorporates transparent address latches to reduce the number of support IC components, enabling a 20-35 nanosecond access time.
For More Information Circle No. 560

Entropic Research Laboratory, Inc., Washington, DC, has released HTK, the Hidden Markov Model (HMM) Toolkit, a **speech recognition software kit** that permits users to build HMM pattern recognition classification and continuous speech recognition systems. It can be applied to speech processing applications such as speaker verification, automatic speech transcription, and key work spotting, as well as bioacoustic research, target identification, and financial time series analysis.
For More Information Circle No. 561

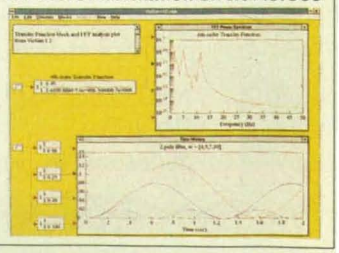
The Spectrum line of industrial **ultrasonic NDT transducers** introduced by Staveley Sensors, Inc., East Hartford, CT, offers improved performance, repeatability, and durability compared to conventional transducers; A 5 MHz, 0.5" diameter transducer provides a +21 dB gain improvement and equivalent flaw resolution. The transducers are available in all common US and international frequencies from 1 MHz to 10 MHz and diameters from 5 mm to 1 inch, and with high-penetration or high-resolution contact and replaceable face designs.
For More Information Circle No. 562

Viewgraphics Inc., Mountain View, CA, has introduced the Viewstore 5000 **frame buffer** to enable real-time capture, storage, and display of large amounts of image data and video sequences. The system features an aggregate memory capacity of up to 9 gigabytes—enough storage for 2 minutes of high-resolution video, more than 8 minutes of traditional digital video, or 50K x 50K pixel RGB true-color images.
For More Information Circle No. 563

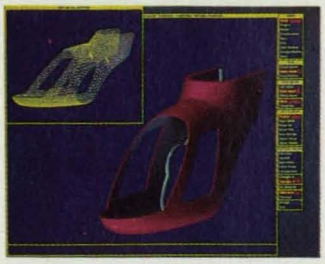
The EasyCopy™ line of **imaging application printers** from JRL Systems, Austin, TX, incorporates sophisticated controller technology to accept compressed raster data in CCITT Group 3 and Group 4. Data is decompressed on board, freeing the workstation or host. The printers accept a wide range of Group 4 headers including TIFF, TRIF, CALS, IOCA, MODCA, ACCESS, ACRIS, and FORMTEK.
For More Information Circle No. 564

The first **emulative tester** that can test digital circuit boards running at speeds of 50 MHz and higher has been announced by Innovage Technologies, Inc., Mukiteo, WA. Applicable to 16-bit and 32-bit microprocessor-based digital boards, the Innovage 2000 eliminates signal propagation delays to reduce test development times by half or more.
For More Information Circle No. 565

Visual Solutions Inc., Westford, MA, has released an update of VisSim™, its continuous and discrete multirate **systems design and simulation software**. VisSim features a visually programmed design environment running under Windows and UNIX/X. Version 2.1 offers Fast Fourier Transform plots of simulation results for analysis in the frequency domain, the ability to import results directly from MATLAB®, and a stiff equation solver to speed simulations dominated by high-frequency terms.
For More Information Circle No. 566



New on the Market



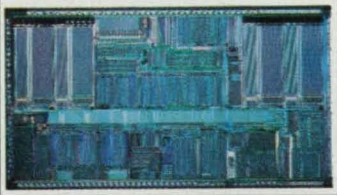
Parametric Technology Corp., Waltham, MA, has released a video demonstration of its Pro/ENGINEER **mechanical design automation tool**, which integrates the entire design-through-manufacturing process. The parametric, feature-based solid modeling system offers a single data structure to enable all members of a product development team to work on a design concurrently. Models are created as combinations of design-specific features such as ribs, slots, chamfers, and shells—eliminating the need to design with complete geometry. Pro/ENGINEER runs on more than 50 UNIX workstations from such vendors as Digital Equipment Corp., Hewlett-Packard, IBM, Sun Microsystems, and Silicon Graphics.
For More Information Circle No. 575

Spiral Software, Brookline, MA, has released a Windows version of EasyPlot, **technical plotting and data analysis software** offering the speed and simplicity of interactive graphics. Compatible with DOS-based EasyPlot, EPWin features a new spreadsheet-like data editor, a text toolbar for mathematical text editing, user-definable function-key macros, and "clipboard-plotting" that lets users graph data directly from the clipboard without first pasting into a data table.
For More Information Circle No. 576

GPIBLab, **software** that allows **instrument setup and data collection from IEEE-based instruments without programming**, is available from DSP Development Corp., Cambridge, MA. When integrated with the DADiSP graphical data analysis software package, GPIBLab collects, analyzes, and displays scientific and technical data. Priced at $495, the software supports National Instruments, IOtech, and Hewlett-Packard boards.
For More Information Circle No. 577

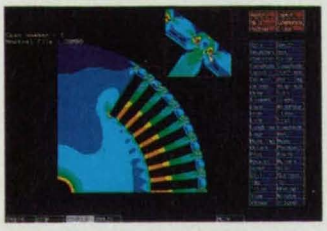
EES, an **equation-solving program** from F-Chart Software, Middleton, WI, incorporates thermodynamic and transport property functions for many substances including water, all common refrigerants, nitrogen, methane, propane, helium, and moist and dry air. Thermophysical property functions are integrated with the nonlinear equation solving capability and a parametric table permits automation of multiple solutions.
For More Information Circle No. 579

The T9000, the fastest available **single chip computer**, has been announced by the INMOS division of SGS-Thomson Microelectronics, London, UK. It provides 200 MIPS, 25 MFLOPS peak performance, a 32-bit superscalar integer processor, a 64-bit floating point unit, a virtual channel processor, and 100 MB/sec communications links—all on a 10 x 20 mm chip.
For More Information Circle No. 580



The FASTCache-PLUS **accelerator board** from Microway, Kingston, MA, speeds up 286 systems by a factor of seven or more and has sockets for 16 MB of RAM. It enables a 286 system to run Windows, AutoCAD, UNIX, OS/2, and other products requiring access to the 386's protected mode or to Windows 386 enhanced mode. FASTCache runs on over 100 286 platforms, including systems from IBM, Compaq, Zenith, Epson, AT&T, Olivetti, and Dell. For more information, call 508-746-7341.

An update of weCan, a general-purpose, integrated **design, modeling, and finite element analysis program**, has been released by Aegis Software Corp., Pittsburgh, PA. Version 5.0 has a flexible interface and a choice of operation mode: commands, mouse, keyboard-driven menus, or digitized tablet. The package runs on a variety of computers, including IBM 386/486 PCs, UNIX workstations, DEC VAXs, and CRAY supercomputers.
For More Information Circle No. 581



New Literature

New **hardware and software for data acquisition and IEEE 488 control** are described in the 1993 catalog from IOtech Inc., Cleveland, OH. It showcases the DaqBook/100, the first high-speed, parallel-port-based data acquisition product for both notebook and desktop PCs. The 144-page guide includes instrument controllers, bus analyzers, extenders, and serial-to-IEEE converters.

For More Information Circle No. 582

A brochure released by Intermec Corp., Everett, WA, highlights the JANUS 2010 handheld **data collection computer** featuring 1 MB RAM, 2 MB ROM, 512 K Flash, and two PCMCIA drives for expandable, flexible memory configurations. The 2010 uses Microsoft ROM DOS 5.0 and a 386SLX microprocessor with PC-AT architecture for compatibility with application development tools.

For More Information Circle No. 583

A 125-page **step motor design** guide from the Controls Division of American Precision Industries, Buffalo, NY, provides an illustrated glossary, walk-throughs of step motor technology, formulas for system calculations, a command summary, programming examples, and detailed descriptions and drawings of typical applications. Indexers, step motors, modular drives, packages systems, and accessories are highlighted.

For More Information Circle No. 584

Newport Electronics Inc., Santa Ana, CA, has announced its 1993 **temperature measurement** buyers' guide. Products shown in the full-color catalog include temperature and humidity instrumentation, handheld thermometers, digital multimeters, calibrators, selector switches, panel meters, surface probes, and thermocouple assemblies.

For More Information Circle No. 585

Quiet Islands™ **vibration-isolation platform systems**, designed for microelectronics cleanroom applications, are described in a data sheet released by Technical Manufacturing Corp., Peabody, MA. The systems interspace quiet pedestals in a raised floor system for proper support of sensitive wafer production equipment.

For More Information Circle No. 586

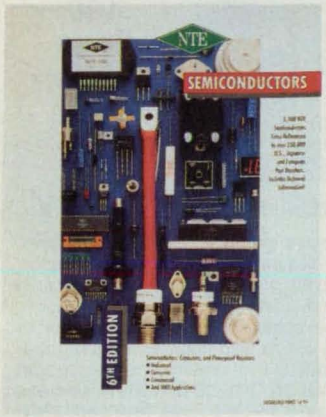
The Analytical Inspection Division of Sonoscan Inc., Bensenville, IL, has published a six-page brochure illustrating its custom **inspection and screening services**. This division, known as SONOLAB™, specializes in nondestructive contract testing of microelectronics components and advanced materials. Featured applications include screening programs for multilayer ceramic capacitors, and quantitative die attach analysis.

For More Information Circle No. 587

New Literature

Daedal, a division of Parker Hannifin Corp., Harrison City, PA, is offering a brochure on its new line of precision ground **leadscrews** for positioning applications that require highly accurate linear motion. The eight-page selection guide features Daeda-Flex™ leadscrews, which provide accuracy to 0.000025", travel lengths up to 14", and are available in both precision and super-precision grades with laser certification.
For More Information Circle No. 588

A technical guide released by NTE Electronics Inc., Bloomfield, NJ, features more than 250,000 US, Japanese, and European devices cross-referenced to NTE's 3500 replacement **semiconductors**. Also available is a catalog cross-referencing NTE's UL- and CSA-recognized relays, sockets, I/O modules, and accessories to over 10,000 industry part numbers from 110 manufacturers.
For More Information Circle No. 589



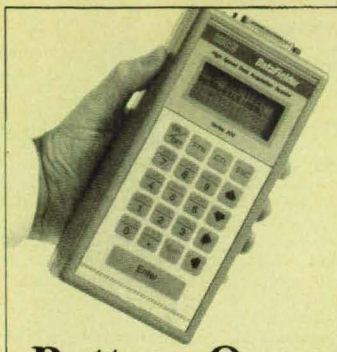
Matra Datavision Inc., Tewksbury, MA, has published a brochure describing Prelude/Solids, a sophisticated **solids modeling system** for any industrial and mechanical design application. Priced at $3995, the system contains many features found in high-end systems, such as generation from profile commands—including extrude, revolve, and sweep—and three feature-creating commands (pocket, solid fillet, and solid chamfers).
For More Information Circle No. 590

PLASMACIZE® **composite coatings**, comprising layers of ultra-fine ceramic particles infused with polymers to enhance structural integrity, are described in a brochure from General Magnaplate, Linden, NJ. True composites of super-hard ceramics, lower modules matrix materials, and dry lubricants, the coatings offer high corrosion, wear, and chemical resistance and can be used on most metals, including aluminum.
For More Information Circle No. 591

A 128-page **temperature measurement and control** catalog has been published by Cole-Parmer Instrument Co., Niles, IL. Featured measurement products include industrial, wall-mount, and pocket bimetal thermometers; cryogenic monitors and probes; glass thermometers including enclosed, NIST-certified, ASTM, and pocket models; infrared thermometers; and RTD, thermistor, and thermocouple meters, probes, and accessories.
For More Information Circle No. 592

Temperature sensors and probes for measurement, control, and compensation are showcased in a catalog from YSI Inc., Yellow Springs, OH. It introduces the company's off-the-shelf probes and provides an easy-to-use chart listing such options as thermistor, lead style, lead length, and material. YSI thermistors provide high sensitivity and interchangeabilities as tight as ±0.05 °C.
For More Information Circle No. 593

A catalog of **precision motion controllers** from Galil Motion Control Inc., Sunnyvale, CA, includes PC, VME, and STD bus cards and industrial packaged controls. Highlighted products include the DMC-100, an advanced PC bus motion controller featuring multiaxis linear and circular interpolation, electronic gearing, 8 MHz encoder inputs, program memory, and programmable I/O.
For More Information Circle No. 594



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For More Information Circle No. 402

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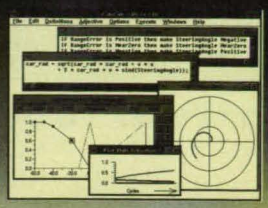

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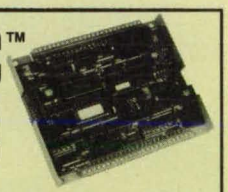

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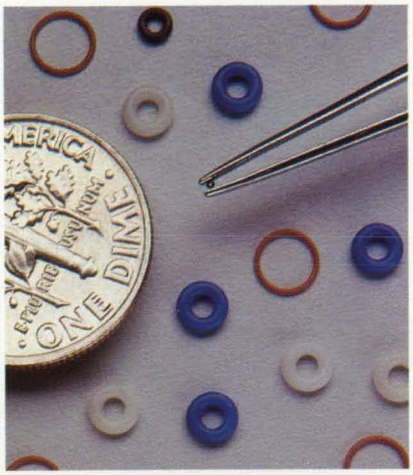

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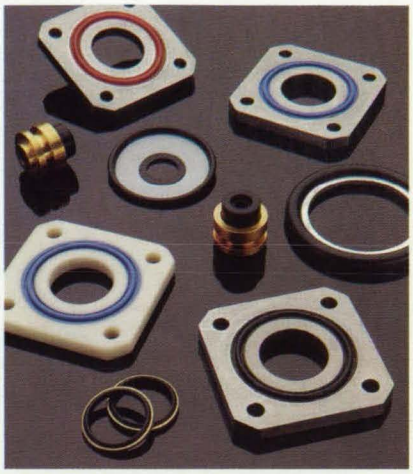

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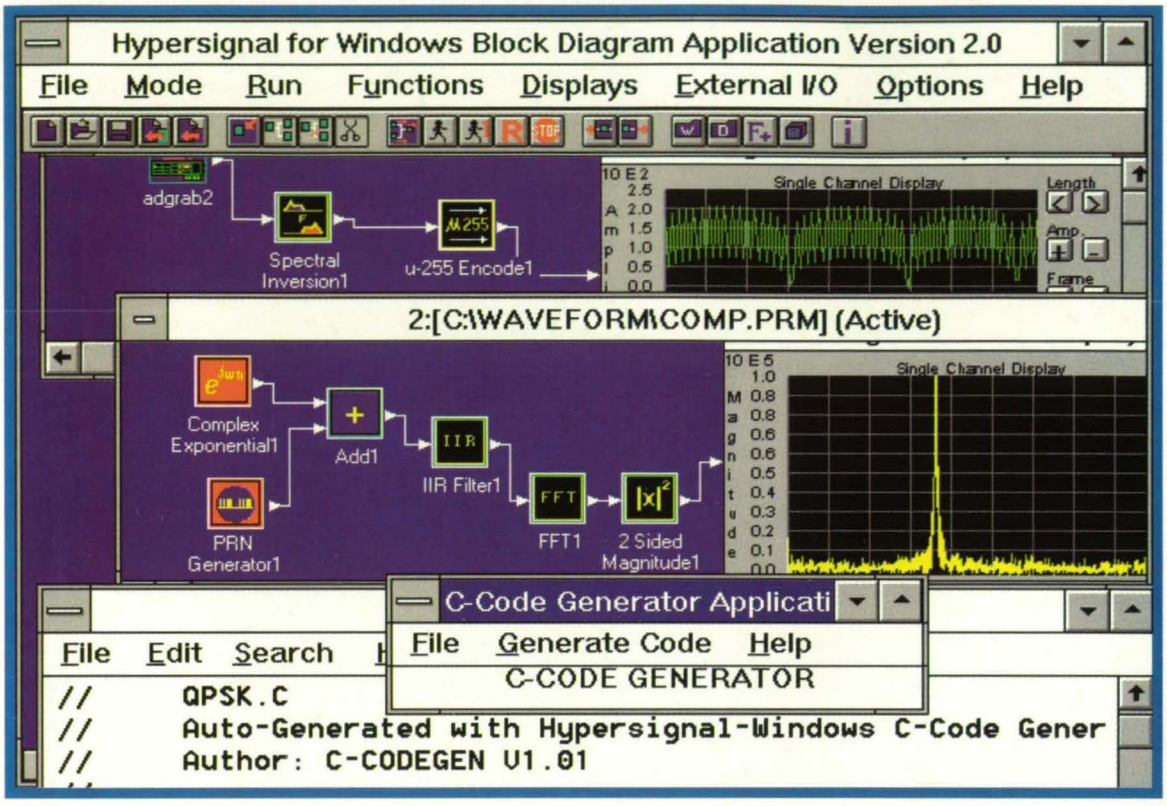

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